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THE
PHILOSOPHY
OF
NATURAL HISTORY.

—
By WILLIAM SMELLIE,

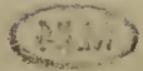
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PREFACE.

EVERY Preface, beside occasional or explanatory remarks, should contain not only the general design of the work, but the motives and circumstances which induced the author to write upon that particular subject. If this plan had been universally observed, prefaces would have exhibited a short, but a curious and useful, history both of literature and of authors. Influenced by this idea, I shall give a very compendious account of the origin, design, and progress of the following work.

ABOUT fifteen years ago, in a conversation with the late worthy, respectable, and ingenious *LORD KAMES*, upon the too general neglect of natural knowledge, His Lordship suggested the idea of composing a Book on the *PHILOSOPHY OF NATURAL HISTORY*. In a work of this kind, he proposed that the productions of Nature, which to us are almost infinite, should, instead of being treated of individually, be arranged under general heads ; that, in each of these divisions, the known facts, as well as reasonings, should be collected and methodised in the form of regular discourses ; that as few technical terms as possible should be employed ; and that all the useful and amusing views arising from the different subjects should be exhibited in such a manner as to convey both pleasure and information.

THIS task His Lordship was pleased to think me not altogether unqualified to attempt. The idea struck me. I thought that a work of this kind, if executed even with moderate abilities, might excite a taste for examining the various objects which every where solicit our attention. A habit of observation refines our feelings. It is a source of interesting amusement, prevents idle or vicious propensities, and exalts the mind to a love of virtue and of rational entertainment. I likewise reflected, that men of learning often betray an ignorance on the most common subjects of Natural History, which it is painful to remark.

I HAVE been occasionally employed, since the period which I have mentioned, in collecting and digesting materials from the most authentic sources. These materials I have interspersed with such observations, reflections, and reasonings, as occurred to me from considering the multifarious subjects of which I have

ventured to treat. I knew that a deliberate perusal of the numerous writers from Aristotle downwards, would require a considerable portion of time. But the avocations of business, and the translating of a work so voluminous as the **NATURAL HISTORY OF THE COUNT DE BUFFON**, rendered my progress much slower than I wished. I now, however, with much diffidence, submit my labours to public opinion. An examination of the **CONTENTS**, however, will convey a more clear idea of the nature of the work than a multiplicity of words. But I thought it proper to prefix a short account of the circumstances and motives which induced me to engage in an undertaking so extensive, and so difficult to perform with tolerable success.

WITH regard to the manner of writing, it is perhaps impossible for a North Briton, in a work of any extent, to avoid what are called **SCOTTICISMS**. But I have endeavoured to be every where perspicuous, and to shun every sentiment or expression which might have a tendency to injure society, or to hurt the feelings of individuals.

INDULGENT readers, though they must perceive errors and imperfections, will naturally make some allowance for the variety of research, and the labour of condensing so much matter into so small a compass. He is a bad author, it has been said, who affords neither an aphorism nor a motto.

I CANNOT refrain from mentioning a circumstance which has often made me uneasy. The expectations of some friends were higher than I was conscious my abilities could reach.

UPON the whole, the general design of this publication is, to convey to the minds of youth, and of such as may have paid little attention to the study of Nature, a species of knowledge which it is not difficult to acquire. This knowledge will be a perpetual and inexhaustible source of manly pleasures; it will afford innocent and virtuous amusement, and will occupy agreeably the leisure or vacant hours of life.

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THE
PHILOSOPHY
OF
NATURAL HISTORY.

CHAPTER I.

Distinguishing characters of Animals, Plants, and Minerals—The Analogies between the plant and animal, arising from their structure and organs, their growth and nourishment, their dissemination and decay.

NATURAL Bodies, when viewed as they have a relation to man, are marked with characters so apparent, that they escape not the observation of the most unenlightened minds. In a system where all the constituent parts have a reciprocal dependence, and are connected by relations so subtle as to elude the perception of animals, such obvious characters were indispensable. Without them, neither the affairs of human life, nor the functions of the brute creation, could be carried on. Characters of this kind are accommodated to the apprehension of brutes and of vulgar men.

But, when the productions of nature are more closely examined; when they are scrutinized by the eye of philosophy, the number of their relations and differences is discovered to be almost infinite; and their shades of discrimination are often so delicate, that no sense can perceive them. Nothing

apparently, is more easy than to distinguish an animal from a plant ; and yet the proper distinction has puzzled the most acute enquiries, and perhaps exceeds the limits of human capacity.

‘A plant,’ says Jungius, ‘is a *living* but not a *sentient* body, which is fixed in a determined place, and grows, increases in size, and propagates its species*.’ In this definition living powers are ascribed to vegetables ; but they are denied the faculty of sensation. Life, without some degree of sensation, is an incomprehensible idea. An animal limited to the sense of feeling alone, is the lowest conception we can form of life. Deprive this being of the only sense it possesses, and, though its figures should remain, we would instantly conclude it to be as inanimate as a stone. The life attributed to plants seems to be nothing more than an analogical deduction from their growth, nutrition, continuation of their species, and similar circumstances.

Ludwig defines vegetables to be ‘natural bodies, always endowed with the same form, but deprived of the power of local motion†.’ Every branch of this definition is, with equal propriety, applicable to precious stones, salts, and some animals ; and, therefore, requires no farther attention.

Sir Charles Linnaeus, in his *Fundamenta Botanica*, intends to discriminate the three kingdoms of nature in two lines. ‘Stones,’ says he, ‘grow ; vegetables grow and *live* ; animals grow, live, and *feel* ‡.’ This is an assemblage of words, the meaning of which is entirely perverted. The idea of growth implies nutrition and expansion by the intervention of organs. The magnitude of stones may be augmented by an accretion of new matter. But this is not growth, or expansion of parts. The second definition, ‘that vegetables grow and *live*,’ is equally inaccurate. Instead of proving

* Raii Hist. Plant. p. I.

† Ludwig, Phil. Bot. p. I.

‡ Fund. Bot. § 2.

the life of plants, Linnaeus takes it for granted, and makes it the characteristic between vegetables and brute matter. The third, ‘that animals grow, live and *feel*,’ is not less exceptionable. Growth, life, and mere sensation, convey the most ignoble notions of animated beings. From this definition, we would be led to imagine, that Linnaeus meant to describe the condition of a polypus or an oyster. All animals, it is true, grow, live, and feel; but these are only the passive properties of animals. The definition includes none of those instinctive, intellectual, and active powers which exalt the animal above the vegetable, and so eminently distinguish the different tribes from each other.

These and many other abortive attempts have been made to ascertain the precise boundaries between the animal and vegetable. Definitions have been the perpetual aim of most writers on this subject. But definitions, when applied to natural objects, must always be vague and elusive. We know not the principle of animal life. We are equally ignorant of the essential cause of vegetable existence. It is vain, therefore, to dream of being able to define what we never can know. We may, however, discover some qualities common to the animal as well as to the vegetable.

Sensation, motion, and structure of parts, give animals a more extensive range in their connection with external objects. A certain portion of intellect, joined to the vital principle, seem to be the most distinguishing properties of animals, and to constitute their essence or being. Animals will, determine, act, and have a communication with distant objects by their senses. They have the laws of nature, in some measure, at command. They protect themselves from injury by employing force, swiftness, address, and cunning. But vegetables remain fixed in the same place, and are subject to every thing that moves. Animals eat at intervals; their food requires time for digestion, and to answer the complica-

ted purposes of secretion and nutrition. The structure of plants is more simple ; they receive perpetual nourishment without injury. Animals search for and select particular kinds of food. But plants must receive whatever is brought to them by the different elements. Animals exist on the surface and in the interior parts of the earth, in the air, in water, in the bodies of men and other animals, in the internal parts of plants, and even in stones. But if we except a few aquatics, plants are fixed to the earth by roots.

All animals, it has been affirmed, have a heart, or particular fountain for propelling and distributing their fluids to the different parts of their bodies : but caterpillars, and many other insects, have no such general receptacle.

The loco-motive faculty has been considered as peculiar to animals. But even this character is extremely suspicious. Oysters, sea-nettles, the gall-insects, and a variety of other animals, can hardly be said to enjoy the power of local motion. Many species remain forever fixed to the rocks on which they are produced, and have no motion but that of extending or contracting their bodies. Besides, examples of different kinds of motion are discoverable in the vegetable kingdom. When the roots of a tree meet with a stone, or any other obstruction to their motion, in order to avoid it, they change their former direction. They turn from barren to fertile earth, which indicates something analogous to a selection of food. Like the polypus, plants, when confined in a house, uniformly bend toward the window or aperture through which the rays of light are introduced.

The sensitive plant possesses the faculty of motion in an eminent degree. The slightest touch makes its leaves suddenly shrink, and, together with the branch, bend down toward the earth. But the moving plant, or *hedyosarum movens*, of which there are specimens in the botanic garden of Edinburgh, furnishes the most astonishing example of ve-

getable motion. It is a native of the East Indies. Its movements are not excited by the contact of external bodies, but solely by the influence of the sun's rays. The motions of this plant are confined to the leaves, which are supported by long flexible foot stalks. When the sun shines, the leaves move briskly in every direction. Their general motion however, is upward and downward; but they not unfrequently turn almost round; and then their footstalks are evidently twisted. These motions go on incessantly as long as the heat of the sun continues; but they cease during the night, and when the weather is cold and cloudy. Our wonder is excited by the rapidity and constancy of the movements peculiar to this plant. The frequency, however, of similar motions in other plants, renders it probable that the leaves of all vegetables move, or are agitated by the rays of the sun, though many of these movements are too slow for our perception.

The American plant called *dionaea muscipula*, or *Venus's fly-trap*, affords another instance of rapid vegetable motion. Its leaves are jointed, and furnished with two rows of strong prickles. Their surfaces are covered with a number of minute glands, which secrete a sweet liquor, and allure the approach of flies. When these parts are touched by the legs of a fly, the two lobes of the leaf instantly rise up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death. If a straw or a pin be introduced between the lobes the same motions are excited.

When a seed is sown in a reversed position, the young root turns downwards to enter the earth, and the stem bends upward into the air. Confine a young stem to an inclined position, and its extremity will soon assume its former perpendicular direction. Twist the branches of any tree in such a manner that the inferior surfaces of the leaves are turned towards the sky, and you will, in a short time, per-

ceive that all these leaves resume their original position. These motions are performed sooner or later, in proportion to the degree of heat, and the flexibility of the leaves. Many leaves, as those of the mallow, follow the course of the sun. In the morning, their superior surfaces are presented to the east ; at noon, they regard the south ; and, when the sun sets, they are directed to the west. During the night, or in rainy weather, these leaves are horizontal ; and their inferior surfaces are turned toward the earth.

What has been denominated the sleep of plants, affords an instance of another species of vegetable motion. The leaves of many plants fold up during the night ; but at the approach of the sun, they expand with renewed vigour. The common appearances of most vegetables are so changed in the night, that it is difficult to recognize the different kinds, even by the assistance of light.

The modes of folding in the leaves, or of sleeping, are extremely various. But it is worthy of remark, that they all dispose themselves so as to give the best protection to the young stems, flowers, buds, or fruit. The leaves of the tamarind tree contract round the tender fruit, and protect it from the nocturnal cold. The cassia or senna, the glycine, and many of the papilionaceous plants, contract their leaves in a similar manner. The leaves of the chickweed, of the asclepias, atriplex, &c. are disposed in opposite pairs. During the night, they rise perpendicularly, and join so close at the top, that they conceal the flowers. The leaves of the fida or althea theophristi, of the ayenia, and oenothera, are placed alternately. Though horizontal, or even depending, during the day, at the approach of night they rise, embrace the stem, and protect the tender flowers. The leaves of the solanum, or nightshade, are horizontal during the day ; but, in the night, they rise and cover the flowers. The Egyptian vetch erects its leaves during the

night, in such a manner that each pair seem to be one leaf only. The leaves of the white lupine, in the state of sleep, hang down, and protect the young buds from being injured by the nocturnal air.

These and similar motions are not peculiar to the leaves of plants. The flowers have also the power of moving. During the night, many of them are inclosed in their calixes. Some flowers, as those of the German spurge, geranium striatum, and common whitlow grafts, when asleep, hang their mouths toward the earth, to prevent the noxious effects of rain or dew.

The cause of those movements which constitute the sleep of plants, has been ascribed to the presence or absence of the sun's rays. In some of the examples I have given, the motions produced are evidently excited by heat. But plants kept in a hot-house, where an equal degree of heat is preserved both day and night, fail not to contract their leaves, or to sleep, in the same manner, as when they are exposed to the open air. This fact evinces, that the sleep of plants is rather owing to a peculiar law, than to a quicker or slower motion of their juices.

A stomach and brain have been reckoned essential characteristics of the animal ; and plants are said to possess nothing analogous to these organs. But the polypus has no stomach ; or rather, like vegetables, its whole body may be considered as a stomach. Its internal cavity contains no viscera ; and, when this animal is turned outside in, it still continues to live, and to digest its food, in the same manner as if it had received no injury. The mode by which plants are nourished is extremely analogous. They imbibe food by the roots, the trunk, the branches, the leaves, and the flowers. Instead, therefore, of having no stomach, their whole structure is stomach. With regard to the brain, the polypus, and many other insects, are deprived of that organ. Hence neither

stomach nor brain are essential characters which discriminate the animal from the vegetable.

But all animals are endowed with sensation, or at least with irritability, which last has been considered as a distinctive character of animal life. Sensation implies a distinct perception of pleasure and pain. We infer the existence of sensation in organized bodies, when we perceive that they have organs similar to our own, or when they act, in certain circumstances, in the same manner as we act. If an organized being has eyes, ears, and a nose, we naturally conclude that it enjoys the same sensations as these organs convey to us. If we see another being, whose structure exhibits nothing analogous to our organs of sensation, contracting with rapidity when touched, directing its body uniformly to the light, seizing small insects with *tentacula*, or a kind of arms, and conveying them into an aperture placed at its anterior end, we hesitate not to pronounce that it is animated. Cut off its arms, deprive it of the faculty of contracting and extending its body, the nature of this being will not be changed ; but we will be unable to determine whether it possesses any portion of life. This is nearly the condition of the final sections of a polypus, before their heads begin to grow. The wheel-animal, the eels in blighted wheat, and the snails recorded in the philosophical transactions, afford instances of every appearance of sensation, or even of irritability, being suspended, not for months, but for several years, and yet the life of these animals is not extinguished ; for they uniformly revive upon a proper application, of moisture.

These and similar facts show, that we are entirely ignorant of the essence and properties of life. What life really is, seems too subtle for our understanding to conceive, or our senses to discern. If we have no other criterions to distinguish life, than motion, sensation, and irritability, the animals just mentioned continued for years in a state which every man

would pronounce to have been perfectly dead. It is possible, therefore, that life may exist in many bodies which are commonly thought to be as inanimate as stones. Hence it would be rash to exclude plants from every species of sensation. The degrees of sensation decrease imperceptibly from man to the sea-nettle, gall-insects, and what are called the most imperfect animals. Every vegetable, as well as the sensitive plant, shrinks when wounded. But, in most of them, the motion is too slow for our perception. When trees grow near a ditch, the roots which proceed in a direction that would necessarily bring them into the open air, instead of continuing this noxious progress, sink below the level of the ditch, then shoot across, and regain the soil on the opposite side. When a root is uncovered, without exposing it to much heat, and a wet sponge is placed near it, but in a different direction from that in which the root is proceeding, in a short time the root turns towards the sponge. In this manner the direction of roots may be varied at pleasure. All plants make the strongest efforts, by inclining, turning, and even twisting their stems and branches, to escape from darkness and shade, and to procure the influences of the sun. Place a wet sponge under the leaves of a tree, they soon bend downward, and endeavour to apply their inferior surfaces to the sponge. If a vessel of water be placed within six inches of a growing cucumber, in twenty-four hours the cucumber alters the direction of its branches, bends either to the right or left, and never stops till it comes into contact with the water. When a pole is placed at a considerable distance from an unsupported vine, the branches of which are proceeding in a contrary direction from that of the pole, in a short time, it alters its course, and stops not till it clings around the pole.

Facts of this kind excite our wonder ; but they by no means prove that vegetables live, or that they are endowed

with sensation, which implies a distinct perception of pleasure and pain.

There is an inferior species of sensation, which is distinguished by the term *irritability*. This term denotes that power by which muscular fibres, even after they are detached from the body, contract upon the application of any stimulating substance, whether solid or fluid. The heart of a frog when pricked with the point of a pin continues to beat, or to contract and dilate, for several hours after it has been cut out of the animal's body. The heart of a viper or of a turtle beats distinctly from twenty to thirty hours after the death of these animals. The peristaltic motion of the intestines is produced by their irritability. When the intestines of a dog, or any other quadruped, are suddenly cut into different portions, all these portions crawl about like worms, and contract upon the slightest touch. Though irritability be unquestionably a vital principle, yet it is equally certain that muscular fibres, when separated from the body to which they belong, have no distinct perception of pleasure or pain. Their regular contraction and dilatation are evident symptoms of life, which, in many cases, may lead us to attribute living powers to substances that enjoy neither life nor sensation. Hence, though all plants were irritable, this circumstance would not prove that they are possessed of life. The contraction and dilatation of the sensitive plants, and the various motions of the leaves, branches, flowers, and roots of vegetables formerly mentioned, seem to indicate that most plants are endowed with irritability. Perhaps all vegetables have more or less of this quality. The heart, intestines, and diaphragm, are the most irritable parts of animal bodies ; and, to discover whether this quality resides in all plants, experiments should be made chiefly on their leaves, flowers, buds, and the tender fibres of the roots.

From this narration of facts, it appears, that plants make a very near approach to animals; and that this similarity, as well as the difficulty of fixing the precise boundaries by which these two great kingdoms of nature are limited, are direct consequences of the organization of vegetables. It is owing to their organic structure alone, that plants and animals are capable of affording reciprocal nourishment to each other. This organic structure, though greatly diversified in the different species of animals and vegetables, evinces that nature in the formation of both, has acted upon the same general plan. May we not presume, therefore, as plants as well as animals are composed of a regular system of organs, that the vegetable part of the creation is not entirely deprived of every quality which we are apt to think peculiar to animated beings? I mean not to insinuate, that plants can perceive pleasure or pain. But, as many of their motions and affections cannot be explained upon any principle of mechanism, I am inclined to think, that they originate from the power of irritability, which, though it implies not the perception of pleasure and pain, is the principle that regulates all the vital or involuntary motions of animals. To ascertain this point, would require a set of very nice experiments. I shall mention one, which might be performed with tolerable ease. It was formerly remarked, that plants kept in a hot house, where the degree of heat is uniform, never fail to sleep during the night. This is direct evidence, that heat alone is not the cause of their vigilance. But they are deprived of light. Let, therefore, a strong artificial light, without increasing the heat, be thrown upon them. If, notwithstanding this light, the plants are not roused, but continue to sleep as usual, then it may be presumed that their organs, like those of animals, are not only irritable, but require the reparation of some invigorating influence which they have lost while awake, by the agitations of the air and the sun's rays, by the act of growing, or by some other latent cause.

It is almost unnecessary to mark the distinction between vegetables and minerals. The transition from the animal to the plant is effected by shades so imperceptible, as to elude the most acute observers. But, between the plant and the mineral, there is a vast chasm in the chain of being, which may be the source of great discoveries. In bodies purely mineral, not a vestige of organization can be discovered. The fibrous structure of the asbestos has been regarded as an approach towards organization, and as the link which connects the mineral to the vegetable kingdom. But this is one of those strained analogies which are too often employed by theoretical writers. Though the asbestos is composed of a kind of threads or fibres, these fibres are not tubular ; neither are they interwoven, like that regular tissue or fabric which so remarkably distinguishes organized from brute matter. Of course, the magnitude of the asbestos can only be increased by the apposition of new matter, and not by any developement or expansion of parts. But though, in the mineral kingdom, nature ceases to organize, she continues to arrange.

The regular configuration of salts, chrystals, and other precious stones, has been considered by some authors as the result of an organic process. But the uniform figure of salts and chrystals may be the effect of certain laws of attraction peculiar to each species. None of these particles can be regarded as a germ or bud. They are only the elements or constituent parts, which, when applied to each other, form a whole. They never expand or grow, like the embryos of animals or plants. They remain for ever in the same state without diminution or increase, except when separated by force, or magnified by an accumulation of fresh matter. The chrystalline juice is not assimilated by vessels : It is prepared by a chymical operation of nature. The bodies of plants and animals are machines, exceedingly elaborate, and more

or less complicated. These machines, by means of different organs, have the power of converting other animals and vegetables into their own substance. By this assimilation, all their dimensions are increased ; and their various parts uniformly preserve the same proportions with regard to each other, and continue to perform their respective functions. Besides, organized bodies not only multiply their species, but some of them possess the power of reproducing such parts as are forcibly abstracted from them.

In these and many other qualities common to the animal and vegetable, there is not the smallest analogy to be found in the mineral kingdom. Between the most regular fossils, as salts and chryystals, and the most imperfect animal or vegetable, the distance is immense. Figured fossils are not more organized than a column or a portico. In the formation of the former, nature, in that of the latter, man, is the artist. When no similarity is to be discovered in those fossils which are nearly uniform in their configuration, we are not to expect it in the more loose and irregular parts of brute matter. Here, nature, regardless of symmetry, conjoins heterogeneous materials of which she composes irregular masses. Many stones, flints, and other concretions, afford examples of this kind. More art, it must be acknowledged, appears in the formation of metals : but their structure exhibits no vestiges of organization,

ANALOGIES.

HAVING shown the extreme difficulty of fixing the boundaries which separate the animal from the vegetable kingdom, I proceed to the more pleasing task of enumerating some of those beautiful analogies which subsist between them. To render this subject the more agreeable and instructive, instead of bringing together an unconnected mass, I shall trace the analogies between the animal and plant, under the arrangement of *structure and organs, growth and nourishment, dissemination and decay.*

STRUCTURE AND ORGANS.

IN all organized bodies, a similarity of structure seems to be unavoidable. The bodies of men and quadrupeds consist of a series of connected bones, which run from the head to the rump. This series is known by the name of the *back-bone*, from each side of which, a number of arched bones proceed. Some of these join the breast-bone by means of cartilages, and form a vaulted cavity, which contains and defends the heart, and other viscera proper to the chest. The bones of the pelvis, and of the four extremities, are joined to the back-bones by articulations and membranes. By the same contrivance, the cranium is fixed to the upper end of the back bones. Into different processes and portions of all these bones, a great number of muscles, or bundles of fleshy fibres are inserted. These muscles are the instruments which give rise to all the varieties of animal motion. The bones of the head, or cranium, contain the brain and cerebellum, a prolongation of which runs through the whole extent of the canal in the back-bone, and is known by the term *spinal marrow*. From the brain and spinal marrow proceed all the nerves, or instruments of sensation. These nerves, the ramifications of which are infinitely various and minute, are distributed upon the heart, lungs, blood vessels, bowels, and muscles, till they terminate on the skin, or external covering of the body. The heart is the fountain, or general receptacle of the blood. The contraction of the heart propels the blood through the arteries, which are likewise distributed, by numerous and complicated ramifications, over every part of the body, and terminate in the veins, which again collect the whole arterial blood into one cavity, and reconvey it to the heart. This circulatory process goes on during life.

Beside the organs already mentioned, there are others, termed *secretory*, because they separate peculiar fluids from

the general mass of circulating blood. The stomach and intestines are furnished with a vast number of small tubes, called *lacteal ducts*, which separate and absorb the nutritious parts of the aliment, and reject all the grosser and useless particles. These ducts, after innumerable communications with each other, unite into one large tube, distinguished by the name of the *thoracic duct*, which is the general reservoir of the chyle, or secreted liquor. This chyle, which is a mild fluid, passes from the thoracic duct to the subclavian vein ; and by this vein it is conveyed to the heart, where it mingles with the blood, and is circulated through the body, for the nourishment of its different parts. It is of no moment, for our present purpose, to be more particular, especially as this subject will be afterwards more fully handled. I shall therefore just mention, that there are particular organs or glands for secreting various fluids, which are necessary to the existence of the larger animals, as the kidneys for the secretion of urine ; the liver for the secretion of gall ; the stomach for the secretion of the gastric juices ; the salivary glands for the secretion of saliva, &c.

From this sketch of the structure of man and of quadrupeds, very little attention is necessary to perceive, that nature pursues a similar plan in the formation of birds and fishes.

In that numerous class of animals distinguished by the name of *insects*, there is a great variety of form and structure. In many of these, nature seems to depart from her general mode of operation. But, upon a more accurate examination, this seeming departure will appear to be only an extension of that universal plan which she observes in the formation of all animated beings. Some insects, the lobster, and all the crustaceous and shell animals, have their bones on the outside of their bodies. To these bones the muscles and other instruments of motion are attached. Many species have no bones ; but their bodies consist of a succession of rings incap-

fed into each other. By contracting and dilating these rings, all the movements of this kind are performed. The head, in some species, changes its form every moment. It contracts or dilates, appears or disappears, at the pleasure of the animal. These motions are permitted by the flexibility of the membranes, or coverings of the head. In other species, the form of the head is permanent, owing to the hardness of the coverings, which are scaly or crustaceous, and approaches nearer to that of the more perfect animals.

Many insects are destitute of particular organs. Some want eyes, ears, brain, and nostrils. Other have an acute sense of smelling, though we know not the form nor situation of the organ. The inferior species of insects have no internal lungs, but receive air by lateral pores, and sometimes by long tubes, or tracheae, which protrude from different parts of the body. Many insects have no heart, or general reservoir for the reception and propulsion of the blood. But we discover by the microscope, that their blood circulates by the pulsation of arteries, and that their different fluids are secreted by glands. In a word, nature, in the structure and functions of animals, descends, by degrees almost imperceptible, from man to the polypus, a being which, ever since its oeconomy and properties were discovered by M. Trembley, has continued to astonish both philosophers and naturalists. The structure of the polypus, which inhabits fresh water pools and ditches, is extremely simple. Its body consists of a single tube, with long *tentacula*, or arms, at one extremity, by which it seizes small worms, and conveys them to its mouth. It has no proper head, heart, stomach, or intestines of any kind. This simplicity of structure gives rise to an equal simplicity in the oeconomy and functions of the animal. The polypus, though it has not the distinction of sex, is extremely prolific. When about to multiply, a small protuberance or bud appears on the surface of its body. This bud gradually swells and ex-

tends. It includes not a young polypus, but is the real animal in miniature, united to the mother as a sucker to the parent tree. The food taken by the mother passes into the young by means of a communicating aperture. When the shooting polypus has acquired a certain growth, this aperture gradually closes, and the young drops off, to multiply its species in the same manner. As every part of a polypus is capable of sending off shoots, it often happens, that the young before parting from the mother, begin to shoot ; and the parent animal carries several generations on her own body. There is another singularity in the history of the polypus. When cut to pieces in every direction fancy can suggest, it not only continues to exist, but each section soon becomes an animal of the same kind. What is still more surprising, when inverted as a man inverts the finger of a glove, the polypus seems to have suffered no material injury ; for it soon begins to take food, and to perform every other natural function. Here we have a wonderful instance of animal ductility. No division, however minute, can deprive these worms of life. What infallibly destroys other animals, serves only in the polypus, to multiply the number of individuals. M. Trembley, in the course of his experiments, discovered, that different portions of one polypus could be ingrafted on another. Two transverse sections brought into contact quickly unite, and form one animal, though each section belongs to a different species. The head of one species may be ingrafted on the body of another. When a polypus is introduced by the tail into another's body, the two heads unite, and form one individual. Pursuing these strange operations, M. Trembley gave scope to his fancy, and, by repeatedly splitting the head and part of the body, formed hydras more complicated than ever struck the imagination of the most romantic fabulists.

This short account of the general structure of animals was a necessary preparation for perceiving more clearly their connection with the vegetable kingdom.

The structure of plants, like that of animals, consists of a series of vessels disposed in a regular order. These vessels are destined to perform the different functions necessary to the nourishment, growth, and dissemination of the plant. In trees, and most of the larger vegetables, three distinct parts are to be observed ; the bark, the wood, and the pith. The bark likewise consists of three parts ; the skin, the body, and the liber, or inner circle ; which last, about the end of autumn, assumes the same texture and firmness with the wood. The substance of the bark is composed of a number of longitudinal sap and air vessels, which have the appearance of fine threads, running from the root to the trunk and branches. Beside these vessels, the bark is furnished with a parenchymatous or pulpy substance, in which there are a vast variety of *folliculi*, or small bladders. The bark is connected to the wood by transverse insertions of the parenchyma.

The wood consists of two distinct substances ; the one is dense, and compact, and constitutes what is termed the *ligneous body* ; the other is porous, moist, and pulpy, and is therefore called the part of the wood. A portion of wood is placed alternately between a similar portion of parenchyma. These alternate portions proceed from the edges of the pith, as *radii* from the center of a circle, widening proportionally as they approach the circumference. Both of them, however, like the bark, are furnished with numberless sap and air vessels.

The pith or heart is bounded on all sides by the wood, and is composed of the same materials : It is nothing but a vast congeries of air and sap vessels, interwoven with the parenchyma and bladders, not unlike the tissue of gauze or lace. This texture is common to every part of the trunk,

being only more close and compact in the bark and wood than in the pith. It is well known that the pith of plants diminishes in proportion to their age. The reason is obvious ; every year the ring of vessels, which lies contiguous to the wood, dries, condenses, and becomes wood.

The leaves of vegetables consist of a fine skin, which incloses the parenchyma or pulp. This skin, like that of animals, is an organic body, furnished with an immense number of parenchymatous and ligneous fibres, and interwoven in a manner precisely similar to that of the trunk and branches. When the skin is removed, the pulp appears, and is every where interspersed with small cylindrical fibres, wound up into minute bladders. A large nerve runs along the middle of every leaf, and continually sends off branches, which gradually decrease in magnitude, till they reach the edge or disc. This principal nerve is a collection of small tubes, which, at proper distances, go off, and are distributed over the leaf in a manner precisely similar to the distribution of the nerves over the human body.

With regard to flowers and fruits, their general texture is the same with that of the parts already described, differing only in various proportions of the ligneous vessels and parenchymatous or pulpy substance. That vegetables are possessed of secretory glands, is apparent from the almost infinite variety of their tastes, odours, and colours. These sensible qualities differ even in different parts of the same plant. But the glandular secretion of vegetables is most conspicuous in the flowers and fruit. Many flowers secrete a nectareous fluid, which is more grateful to the palate than the finest honey. The glands of some fruits, as those of the lemon and orange, secrete liquors of very different qualities. The vessels of the rhind contain an acrid essential oil, while those of the parenchyma or pulp secrete an agreeable acid.

This similarity in the general structure of animals and plants is strongly corroborated by the analogous parts in both being destined to answer the same purposes.

The oeconomy and functions of vegetables, as well as those of animals, are the results of a vascular texture. Each of these classes of beings have vessels destined to the performance of similar offices. In man and quadrupeds, the fluids are circulated by the pulsation of the heart and arteries. The juices of plants do not circulate ; but they are raised from the root to the trunk, branches, leaves, flowers, and fruit by the sap-vessels. The ascension of the sap has been ascribed to capillary attraction. But, though no motion is perceptible in the sap-vessels similar to the pulsation of arteries ; yet, both the propulsion of the sap, which moves with great force, and the secretion of different fluids by different parts of the same plant, imply an action in these vessels. In animals, the gall, the urine, the saliva, are all concocted from the general mass of blood by the action of particular vessels. Fluids of these different qualities exist not in the blood itself ; they are created by an incomprehensible operation of the vessels peculiar to their respective glands. In plants, the sap ascends, and different fluids are secreted from it by glandular vessels. Here the same effects are produced both in the animal and the plant. We must, therefore, attribute them to the same cause, namely, the action of vessels. Besides, the sap, which is the blood of plants, moves with a force often equivalent to the weight of the atmosphere. M. Bonnet remarks*, that he has seen, by means of coloured liquors, the vegetable sap move three inches in an hour ; and Dr. Hales, in his statics, has shown, that the leaves are the principal organs of transpiration. He likewise considers them to be the instruments which raise the sap. But it has since been discovered, that coloured liquors rise equally high in

* Oeuvres, tom. I. p. 140.

branches deprived of leaves, and that they do not rise at all in dried plants. Hence the sap of vegetables is not taken up in the same manner as a sponge imbibes water, but is forced to ascend by an unknown action of the vessels. The spring of the tracheae may put in motion the air they contain, and that air may have some influence on the general movement. But, by whatever powers the sap is moved, the existence of the motion is certain ; and it is equally certain, that this movement of the sap produces the same effects in the vegetable, that the force of the heart and arteries does in the animal.

The motion of the sap in vegetables, is not properly a circulation similar to that of the blood in the more perfect animals. It ascends and descends in the same vessels ; and these motions are evidently affected by heat and cold. The sap rises copiously in a warm day, and descends during the night, nearly in the same manner as the mercury rises and falls in the thermometer. But, though the analogy here fails with regard to man and the larger animals, yet it holds in the tænia, the polypus, and many other insects, which exhibit not the smallest vestiges of circulation in their juices.

The pith, or medullary substance of plants, has some resemblance to the brain and spinal-marrow of animals. When the texture of the brain or spinal-marrow is destroyed, life is extinguished ; and, when the pith of plants is destroyed or dried up by age, they no longer retain the power of vegetating. The leaves of plants are analogous to the lungs of animals. It is by the lungs that the perspiration of animals is chiefly effected : and plants discharge most of their superfluous moisture by the leaves. They expose a large surface to the action of the sun, which produces a transpiration so copious, that some plants throw out fifteen or twenty times more in a given period, than is discharged from the human body. When a plant is deprived of its leaves in summer, instead of

ripening its fruit, it is in great danger of dying for want of those organs which carry off the superfluous juices that arise from the root. A plant, in this situation, may be considered as labouring under an asthma, or dying of a suffocation.

Beside the leaves, plants transpire by the pores of the skin. But the quantity emitted in this manner is not nearly equal to that which issues from the leaves. The same thing happens with regard to man and quadrupeds. Though they likewise perspire through the skin, yet by much the greater quantity of perspirable matter is discharged by the lungs. Beside throwing out superfluous or noxious matter by the leaves, plants, by the same organs, absorb from the atmosphere, and perhaps from the sun's rays, some unknown matter, which is necessary to their existence. The lungs of animals likewise derive, from the same sources, a particular matter or principle, without which life could not long be continued.

Another analogy between the structure of plants and animals merits observation. The round bones of animals consist of concentric strata or plates, which can be easily separated; and the wood of plants consist of concentric layers of hardened vessels, which separate when macerated in water. A tree acquires an additional ring every year; and, by counting these rings, a pretty exact estimation of its age may be attained.

The branches of plants have been considered as analogous to the arms or tentacula of animals. But this is one of those strained analogies which should be carefully avoided. The great use of branches is evident. By producing an amazing number of leaves, a large surface is exposed to the air and sun, to answer the important purposes of transpiration and absorption. If there is any thing in plants analogous to the arms or tentacula of animals, it must be confined to such species as twist themselves around poles or trees, as the ivy, the vine, the convolvulus, &c. and to such as support their trunks on

other bodies by means of little hooks, as the goose-grafts, and many other kinds.

All these analogies, it may be remarked, are confined to large animals and large vegetables; but they hold not in that numerous tribe of plants called *grasses*. Instead of being filled with wood and pith, their stems are perfectly hollow; and, to fortify these plants, Nature has bestowed on them strong joints or knots, which are placed at regular distances in each species. But, though some of the analogies which subsist between the larger animals and vegetables exist not in the smaller plants, this circumstance, instead of infringing, confirms the general plan of nature. To discover the analogies between tubular plants and animals, we must examine the structure of the minuter tribes of animated beings. The grasses have neither pith nor wood internally; and the polypus, the taenia, and many other insects, have no bones, heart, or intestines, but are simple tubes, perfectly resembling the empty stems of the gramineous plants. Besides, the ligneous, or at least the herbaceous part of these plants, is placed on the outside, similar to the crustaceous and shell animals, whose bones are situated externally. Another analogy must not be omitted. The succulent vegetables, such as the house-leek, the mushroom tribes, and many sea-plants, consist almost entirely of a pulpy or parenchymatous substance, and may be crushed to a jelly by the slightest pressure. The texture of worms, caterpillars, and of all the soft insects, is extremely similar to that of the succulent vegetables.

II. GROWTH AND NOURISHMENT.

THE second source of analogies between the plant and animal is derived from the modes of their growth and nourishment.

Many ingenious theories have been invented, with a view to explain the mysterious operation by which the growth

and nourishment of animals and vegetables are effected. But I shall confine myself, at present, to such remarks as are purely analogical, and may be fully understood without a minute knowledge of the different ways by which growth and nourishment have been supposed to be accomplished.

Animals, like vegetables, gradually expand from an embryo or gelatinous state, and, according to their kinds, arrive sooner or later at perfection. This expansion and augmentation of substance is the idea conveyed by the word *growth*. Without some nutritious matter taken into the body, and assimilated, by the action of vessels, to the substance of the being that receives it, growth cannot take place. Moisture is the chief food of plants. But the food of animals, in general, varies with the species. This fact led some philosophers to conclude, that every plant extracted from the soil a food peculiar to its own nature. It was, however, afterwards discovered, by repeated experiments, that vegetables can grow, and acquire a very considerable degree of bulk and weight, without exhausting a perceptible quantity of the earth in which they are planted. These experiments are a sufficient proof, that moisture constitutes the chief nourishment of plants. They likewise indicate, that vegetables, however diversified in their figure, density, and fibrous arrangement, are more simple in their texture than animals. But, notwithstanding these seeming differences in the nourishment of plants and animals, Nature fails not to observe the same course in both kingdoms. The food of the animal, before it is converted into nourishment, must go through the intricate process of digestion. But, after the food has been converted into chyle, and the chyle into blood, this blood becomes a common fluid, from which all nourishment and all animal fluids are derived. Here the analogy is apparent. Moisture is to the plant precisely what blood is to the animal.

Each of them extracts its nourishment from a common fluid ; and, in both, this fluid is changed, by the action of vessels, into the various juices peculiar to the different species.

When growth first commences, the embryos of plants and animals are in similar circumstances. Soon after conception, the foetus is inclosed in its membranes, and is nourished, till mature for birth, by blood which it receives from the uterus and placenta. In the same manner, the embryo of a plant is inclosed in the membranes of the seed ; and its fibrous roots are spread over the lobes or pulpy part. After the seed is sown, and vegetation commences, the embryo is nourished by moisture, which the lobes absorb from the earth, and convey it to the minute tubes of the seminal root. In many plants, these lobes rise above the surface of the ground, in the form of leaves, and continue to nourish and protect the tender plume or stem, till it acquires strength sufficient to support the assaults of the air and weather. A plant, in this situation, may be said to have two roots ; one, the fibres of which are diffused through the substance of the lobes, or seminal leaves, and another attached to the soil.

The nourishment thus conveyed to vegetables by the seminal leaves, is extremely analogous to that of animals by the milk of the mother. The texture of young animals is so lax and unelastic, that the food suited to maturer years would soon put a period to their existence. But Nature has provided against this inconvenience. She has endowed females with a set of vessels destined for the secretion of a mild liquor, so far concocted and animalized as to be adapted to the tender and flaccid condition of their young. A similar provision of nourishment is afforded to the young vegetable. For some time after the plume and radicle have begun to shoot, their texture is so extremely tender, that they are unable to support each other without some foreign aid. This aid is afforded them by the seminal leaves. These leaves absorb dews,

air, and other fine fluids, which are concocted and assimilated in the vessels of the seminal root, and then conveyed, in a kind of vegetable form, to the feeble vessels of the plume. Hence it is apparent, that the nourishment of young animals by milk, and of young vegetables by seminal leaves, is the same institution of nature, and effected by similar instruments.

Plants, like animals, pass gradually from an embryo, or infant state, to that of puberty. At this period of their existence, they have acquired that firmness of texture, and that evolution of parts, which constitute the perfection of their natures, and enable them to produce beings every way similar to themselves. In both kingdoms, the age of puberty arrives later or more early, according to the difference of species. Some animals live a few months only. Many of the insect tribes are produced, grow to maturity, propagate their kind, and die in the course of a single season. Others, as several flies, beetles, &c. exist two years. Thus animals have a progressive duration of life. The dormouse lives six years, the hare seven or eight, the bear twenty or twenty five, the camel forty or fifty, the rhinoceros seventy or eighty, the elephant two hundred ; and some birds and fishes are supposed to exist during three or four centuries. The same progressive duration takes place among vegetables. Some plants are annual, as most of the esculent kinds ; others, as the hedge-parsley, the wild carrot, the parsnip, the fox-glove, the scurvy grafts, &c. are biennial ; others exist three, five, seven, ten, twenty, thirty, sixty, and a hundred years ; and the oak, like the elephant and those birds and fishes which are famed for longevity, continues to adorn the forest for several centuries.

The manner by which the nutritious particles are extracted from food, is very similar in the animal and the plant. In the animal, this operation is performed by the lacteal vessels, which are distributed over the internal surface of the stomach and intestines. In the plant, the same office is performed by

the vessels of the root and leaves. Hence animals are organized beings nourished by roots situated within their bodies ; and plants are organized bodies which afford their nourishment by roots placed externally. Besides, in all viviparous animals, the foetus is nourished, not by food taken in at the mouth, but by vessels attached to the placenta. These vessels perform the same office to the foetus, that roots do to vegetables.

Warmth and moisture are favourable to the production of large and juicy plants ; and the animals that feed upon these succulent and rich vegetables, are likewise larger than those which inhabit cold countries, where the plants are smaller, more rigid, and contain fewer nutritive particles.

Some plants grow in particular climates only. The *rubus arcticus*, a species of bramble, so common in Norway and Canada, hardly endures the climate of Upsal, in Sweden. But the *alsine media*, or chickweed, and several grasses, are diffused over almost the whole globe. In the same manner, some animals, as the camel, the rhinoceros, and the elephant, are produced in warm climates only ; while others, as the reindeer, glutton, and marmot, are confined to the colder regions of the earth ; and man, in the animal, like some grasses in the vegetable kingdom, is universal, and inhabits every climate.

Some plants, as well as some animals, are amphibious, as the rush and the frog ; others are parasites, and feed on the juices they extract from the different species to which they adhere. The mistletoe, for example, feeds upon the oak ; most trees afford nourishment to certain mosses and fungous plants ; and every animal is fed upon by smaller kinds.

The growth of plants, like that of animals, may be accelerated or retarded by promoting or checking their perspiration, and by excluding them from proper exercise and air. When men, or other animals, are confined to situations which prevent the free access of pure air, their growth is

retarded ; and their sickly colour indicates a defect of vigour. Plants, when placed in similar circumstances, are always weak, dwarfish, and unnaturally coloured. But exercise is equally necessary to the health and vigour of plants, as it is to those of animals. The exercise of animals is effected by various kinds of spontaneous motion. Plants are likewise exercised by motion ; but that motion is not voluntary ; it is communicated to them by the action of the air. The agitation which they receive from the winds enables them to extend their roots, prevents them from a growth too rapid, and, of course, strengthens their whole fabric. It is owing to the want of this agitation, that plants brought up in houses, or in other confined situations, shoot out to an unnatural length ; that their stems and branches are always slender and weak ; and that they ripen not their fruit like those which are exposed to the open air.

To conclude this branch of the subject, plants and animals are so nearly allied, that their growth and nourishment are not only effected by similar instruments, but some parts of animal bodies evidently partake of a vegetable nature. Thus, the hairs, the nails, the beaks, and the horns, are a species of vegetables, as appears from their comparative total insensibility, as well as from the mode of their growth and reproduction.

III. DISSEMINATION AND DECAY.

WE shall next take an analogical view of the dissemination and decay of the animal and vegetable.

The power of reproduction is peculiar to the plant and animal. Each of them is capable of producing beings every way similar to the parent. But the modes by which this singular effect is accomplished, are very different in appearance. It is our present purpose to remove this apparent difference, and to show that animals and vegetables multiply their species in a manner extremely analogous.

Animals have long been divided into viviparous and oviparous. The one class produce their young alive, the other lay eggs, which must be hatched either by the heat of the sun, or by that of the mother. This division, though very comprehensive, is not perfect. Several animals have lately been discovered which are neither viviparous nor oviparous ; and there are animals which unite both these modes of multiplication.

The viviparous class comprehends men, quadrupeds, and some fishes, reptiles, and insects. The oviparous includes birds, some reptiles, and most of the insect tribes. But the armed polypus, or *hydra* of Linnaeus, instead of being either viviparous or oviparous, multiplies its species, as formerly remarked, by sending off shoots from the body of the parent.

Another species, called the *bell-polypus*, or *hydra flentorea* of Linnaeus, multiplies by splitting longitudinally. In twenty-four hours, these divisions, which adhere to a common pedicle, resplit, and form four distinct animals. These four, in an equal time, again split ; and thus they proceed doubling their numbers daily, till they acquire a figure somewhat resembling a nosegay. The young afterwards separate from the parent stock, attach themselves to the roots or leaves of aquatic plants, and each individual gives rise to a new colony.

The funnel-shaped polypus multiplies by splitting transversely. Of the individuals, accordingly, which proceed from this division, one has the old head and a new tail, and the other a new head and the old tail. The superior division swims off, and fixes itself to some other substance ; but the inferior division remains attached to the former pedicle.

The dart-millepes affords another example of multiplication by spontaneous separation. This insect divides, about two-thirds below the head, into two distinct and perfect animals ; and it seems to possess no other mode of continuing the species.

The multiplication of the various animalcules which appear in infusions of animal and vegetable substances, long occupied the attention, and eluded the researches of philosophers. This discovery of the increase of some larger animals by spontaneous division, gave rise to the conjecture, that these microscopic animalcules might multiply their numbers in a similar manner. This conjecture was communicated to M. de Saussure in a letter from Bonnet, who received an answer, dated at Genoa, September 28, 1769, to the following purpose.

‘What you propose as a doubt,’ says M de Saussure, ‘I have verified by incontestible experiments, namely, that infusion-animalcules multiply by continued divisions and subdivisions. Those roundish or oval animalcules that have no beak or hook on the fore part of their bodies, divide transversely. A kind of stricture, or strangulation begins about the middle of the body, which gradually increases, till the two parts adhere by a small thread only. Then both parts make repeated efforts, till the division is completed. For sometime after separation, the two animals remain in a seemingly torpid state. They afterwards begin to swim about briskly. Each part is only one half the size of the whole ; but they soon acquire the magnitude peculiar to the species, and multiply by similar divisions.’ To obviate every doubt,’ continues our author, ‘I put a single animalcule into a drop of water, which split before my eyes. Next day I had five, the day after, sixty, and, on the third day, their number was so great, that it was impossible to count them*.

‘Another species, with a beak or horn on the fore part of its body, which I obtained from an infusion of hemp-seed, multiplied likewise by division, but in a manner still more singular than the former. This animalcule, when about to

* *La Palingenesie Philosophique*, par C. Bonnet, tom p. 428. 479.

' divide, attaches itself to the bottom of the infusion, contracts
' its body, which is naturally oblong, into a spherical form,
' so that the beak entirely disappears. It then begins to
' move briskly round, sometimes from right to left, and
' sometimes from left to right, the centre of motion being
' always fixed. Towards the end, its motion accelerates,
' and, instead of a uniform sphere, two cross-like divisions
' begin to appear. Soon after, the creature is greatly agi-
' tated, and splits into four animalcules perfectly similar,
' though smaller than that from which they were produced.
' These four increase to the usual size, and each, in its turn,
' subdivides into other four*.' &c.

The beauties of nature have been justly celebrated in the uniformity of her productions. This uniformity was early remarked, and gave rise to the ancient division of animals into viviparous and oviparous, which continued to be adopted as an universal maxim till within these hundred years. Before this period, it was believed by philosophers, that all animals were either brought forth alive, or hatched from eggs. Among the ancients, indeed, and even down to the time of the celebrated Redi, this maxim included chiefly the more perfect animals ; for, with regard to most of the insect tribes, they imagined that these were produced by putrefaction, and the admixture of particular kinds of matter. But Redi, by a series of unquestionable experiments, exploded the doctrine of the equivocal generation of insects ; and then the maxim, without further investigation, was extended to the whole animal kingdom. Redi's experiments and remarks turned the attention of philosophers to the minuter tribes of animals. In the course of a few years, accordingly, several eminent men arose. Reaumur, Bonnet, Trembley, Ellis, Spalanzani, and a multitude of other writers, opened new views with re-

* Idem, p. 430.

gard to the manners and oeconomy of animated beings*. M. Bonnet has furnished incontestible evidence, that several species of the puceron, or vine-fretter, are both oviparous and viviparous. In summer, these insects bring forth their young alive ; but, in autumn, they deposit eggs upon the bark and branches of trees. Here the intention of nature is apparent. The puceron is unable to survive the winter colds; and, therefore, though viviparous during the warm months, the species could not be continued without this wise provision. The puceron, it should appear, is naturally disposed to produce live young. The foetus is inclosed in a membrane, which, like that of the larger animals, bursts before exclusion. But, when the cold season commences, the general texture of the animals, as well as the membranes inclosing the foetus, becomes more firm and tenacious ; and this, perhaps is the physical reason why they are viviparous in summer, and oviparous in autumn. Many other flies are known to be viviparous. Upon further examination, all these will probably be discovered to be also oviparous†.

The puceron exhibits another phaenomenon still more singular. The maxim, that multiplication presupposed impregnation by sexual embraces, was formerly thought to be universal. Neither should the reception of this maxim be regarded as a matter of wonder ; for it was founded on a very general and strong analogy. But the following facts show, that nature, though uniform in many steps of her progress, is not invariably limited to the same mode of operation. On the 20th day of May, M. Bonnet took a young puceron, the moment after dropping from the womb of its mother, and shut it up in a glass vessel, to prevent all possibility of communication with any individual of the species. A sprig of the tree on which the animal was produced, supplied it

* *Traité d'Insectologie*, par C. Bonnet, tom. I. p. 194.—202.

† See *Reaumur*, tom. 8. edit. 12mo, p. 153. et seq.

with nourishment. The creature changed its skin four times, namely, on the 23d, 26th, 29th, and 31st days of the same month. After a minute detail of circumstances, M. Bonnet informs us, that his imprisoned puceron grew with rapidity ; that, on the 1st day of June, it brought forth ; and that, from this day to the 21st, it produced no less than 95 young, all full of life and vigour*. He frequently repeated this experiment, and it was always followed with the same event.

M. Bonnet, suspecting that a single impregnation might influence both the mother and her immediate offspring, resolved to obviate every difficulty. For this purpose, he confined, in separate glasses, young of the successive births, as they dropped from their mothers. Each of these, however, were equally fertile, though he continued the experiment to the ninth generation from the original parent†.

Facts of this kind, which seem to interrupt the ordinary current of nature, should inspire philosophers with caution. They should create reverence for such of her operations as are already known ; but they should likewise check that rash spirit which too frequently draws unlimited conclusions, before the subject be fully investigated. Of all inductions regarding the history of nature, the necessity of sexual commerce for multiplying the species appeared to be the most general and the most legitimate. The oeconomy of the puceron, however, demonstrates, that even this law is not indispensable, and that nature has the power of changing her steps, and of accomplishing the same purposes by various means.

Having enumerated the different modes by which animals multiply their species, I shall next show, that the multiplication of vegetables is extremely analogous.

The viviparous, as well as the oviparous animals, are supposed to proceed from eggs, with this difference, that the

* Bonnet, *Traite d'Insectologie*, tom. I. p. 39. ; and Reaumur, tom. 12. p. 353.

† Bonnet, *Traite d'Insectologie*, tom. I. p. 74. et seq.

young of the viviparous are hatched in the uterus previous to their exclusion.

Many striking analogies subsist between the eggs of animals and the seeds of plants. When placed in proper circumstances, they both produce young every way similar to the parents. To accomplish this wonderful effect, the egg requires impregnation and heat. Moisture, warmth, and soil, or some similar matrix, are necessary for the exclusion of the young plant. This analogy has been extended much farther by Linnaeus, and other supporters of the sexual system of plants. They maintain, that impregnation is equally indispensable to the vegetation of the seed, as to the fertility of the egg. But, as this doctrine will be discussed when we come to treat of sexes in general, we shall here dismiss it without farther remark.

Eggs are not only analogous to seeds, in their general destination of reproducing individuals, and continuing the species, but there is a great similarity in the structure and uses of their respective organs.

The internal parts of the egg are covered with a crust or shell, and two membranes. Beside these, the yoke is included in a separate membrane. When the two first membranes are removed, the white appears every way investing the yoke. In the white, or rather on the membrane of the yoke, a small cicatrice is discernible, in the centre of which is the *punctum saliens*, or embryo of the future animal. After two or three days incubation, this *punctum saliens* becomes red, and shoots out blood-vessels, which are dispersed through the yoke, in the same manner as the vessels of a foetus are distributed over the placenta.

A seed is likewise covered with a shell, or crustaceous membrane. Another membrane invests the whole kernel, or pulpy lobes of the seed. Each lobe, like the yoke of the egg, is involved in a separate membrane. In

every seed there is also a small cicatrice, or aperture, through which the young plant issues. Immediately under this cicatrice, the plume, or future plant, is discernible, resembling the *punctum saliens* of the egg. The branches of the radicle proceed from this plume, and are dispersed through the substance of the lobes, in the same manner as the blood-vessels issue from the *punctum saliens* of the egg, and are distributed over the yoke. It is by the pulp of the lobes that the radicle and plume are nourished, till the one shoots down into the soil, and the other mounts above the surface. In seeds, there is nothing analogous to the white of an egg. Such a provision would have been superfluous; for the earth, in which the seeds are to germinate, must always be moist, otherwise the young plant could not receive nourishment, after issuing from the seed. Besides, the eggs of fishes have no white, because they are perpetually moistened with water.

The analogies arising from the multiplication of animals and plants, by means of eggs and seeds, are the most common, and the most obvious. Eggs and seeds are evidently organs formed on the same plan, and destined by Nature to answer the same general intention: But the multiplication of plants, as well as that of animals, is not confined solely to one mode.

The young of viviparous animals, though they probably originate from small eggs, are not brought forth till they have acquired a certain age and firmness of texture. It may be thought, that there is no multiplication of plants which has any resemblance to that of viviparous animals. We should reflect, however, that plants can multiply by buds. Now, a bud has no analogy, either in texture or appearance, to a seed. Buds arise from the stems or branches of vegetables. One object in their formation is to produce leaves and branches, as well as to extend the length of the trunk or stem. But they are likewise endowed with the faculty of

reproducing new individuals. In this respect, trees and shrubs may be considered as viviparous plants ; because they produce out of their own bodies an organ, which, though differing in every view from a seed, is brought forth alive, and, when properly cherished, is converted into a being perfectly similar to the parent, and capable of continuing its species. The embryo of a bud commences its existence under the bark. Here it remains, for some time, inclosed in membranous coverings, and attached to the bark by minute fibres, which convey to it a nourishment suited to its condition. When arrived at a certain size and consistence, it pierces the bark, and shoots out into the open air. If allowed to remain on the parent, it soon bursts through its membranes, and, in time, gives rise to a new branch : But, when detached from the parent, and placed in proper circumstances, it becomes a new individual of the same species.

Bulbous rooted plants furnish a still stronger analogy between the increase of viviparous animals and that of vegetables. In the end of autumn, if the coats of any bulbous root be carefully dissected, the entire plant in minature will appear in the centre of the root. In spring, this small plant, like a foetus inclosed in the uterus, pierces the coats of which the root consists, and gradually grows till it flowers, ripens its seeds, and dies at the approach of winter, when a new plant is again formed in the old root. Here we have an example of the multiplication of plants similar to that of the puceron ; but the order of time is reversed. The puceron is viviparous in summer, and oviparous in autumn ; but bulbous-rooted plants may be considered as oviparous in summer, and viviparous in autumn.

The same analogy is to be traced in those roots which have what are called *eyes*, like the potatoe. These eyes are all plants in minature, which live in that state during the winter, and, when committed to the soil, come to maturity in summer.

There are still other modes of multiplying common to the animal and vegetable. Many plants are multiplied by suckers, slips, and cuttings.

The animal kingdom furnishes examples of all these modes of multiplication. The suckers of plants have an exact analogy to the shoots of a polypus. When separated from the parent, the sucker becomes a perfect plant, and the shoot of the polypus a perfect animal. Plants are capable of multiplication by slips and cuttings : And the portions of a polypus, however small, or when cut in any direction, reproduce, and become perfect animals of the same species.

But some species of the polypus, the dart-millepes, and several animalcules which appear in infusions of animal and vegetable substances, multiply by splitting, or spontaneous separation. Here the analogy between the animal and vegetable might be supposed to fail. The water-lentil, however, a small plant, which covers the surface of stagnating pools, multiplies its species by detaching thin films from the under side of the leaf. These films or tender leaves produce roots, and vegetate into a regular plant.

We must not dismiss this subject till another analogy be unfolded. All animals have seasons peculiar to their respective kinds. Some of the larger animals produce in the spring, others in summer, others in autumn, and others in winter. With regard to the insect tribes, their seasons are still more various. Every month, every week of the year, gives birth to different species. The seasons of plants are diversified in a similar manner. The growth of different vegetables is distributed over the whole year. Particular tribes spring up at the same uniform periods. In this beautiful diversity of arrangement, the intentions of Nature are evident. If all plants were to rush forward at the same time, they would infallibly choke each other. The surface of the earth could not afford them room. Nature has there-

fore wisely ordained, that the earth should always be covered with plants : But she has also ordained, that particular tribes should die at stated periods, to make way for the existence of others. The same inconvenience would happen if the production of all animals, and particularly that vast number of species, and that immense profusion of individuals, to which the insect tribes give birth, were to take place at one period. The air would be so crowded with noxious creatures, that neither man nor the larger animals could possibly exist. Besides, the species which feed upon particular plants, if they were produced at a time when these plants did not flourish, would infallibly perish for want of food. In Lapland, where the duration of heat is extremely short, the whole insects which inhabit that dreary and barren region are produced in a few weeks. Though the number of species, compared with those of the more prolific climates, be very limited, the inconvenience is severely felt. But every natural evil is accompanied with some advantage. The reindeer, upon which the existence of the Laplanders chiefly depends, are tormented by the swarms of flies. To avoid their numberless enemies, these animals leave the vallies, and ascend the mountains, where the cold is too great for the flies to follow. In these lofty regions, the reindeer feed during the hot season, and return to the vallies after the cold has destroyed the myriads of insects. This forced migration has too good effects : It both preserves the health of the reindeer, and the vegetables in the vallies, which otherwise would have been prematurely exhausted.

The operation of engrafting was long thought to be peculiar to the vegetable kingdom. But M. Trembley found, that several species of the fresh-water polypus could successfully undergo this wonderful process. Since his time, it has been discovered, that the *aælinia*, or sea-nettle, is likewise capable of being engrafted to an individual of the same or of

a different species. In all these instances, the portions of the divided animals grow together, and become distinct individuals.

Having traced the general analogies between the structure and oeconomy of the animal and vegetable, from the rudiments of their existence till they have acquired full maturity, and performed the necessary office of multiplying their species, we proceed to the last and only melancholy branch of this subject, the unavoidable decay and death of every successive individual in both kingdoms.

It is an invariable law of Nature, that all organized bodies should have a constant tendency to dissolution. But the periods of their existence vary according to the species. Previous to actual resolution, plants as well as animals are subject to a number of analogous affections and diseases. When over-heated, plants show evident marks of languor and fatigue : Their leaves become flaccid, their stems and branches bend toward the earth, their juices evaporate, and their whole texture assumes the appearances of weakness and decay. The application of too great a degree of cold makes the flowers, the leaves, the bark, and even the woody fibres, shrivel and contract in their dimensions. When deprived of proper light and air, their colours fade, and they soon acquire a lurid and sickly aspect. They are likewise subject to be starved for want of nourishment. The growth of plants, as well as that of animals, is checked by scanty supplies of food. When the soil or situation is unkindly, vegetables are always weak and dwarfish, and their prolific powers are diminished. They may also be poisoned by the absorption of fluids hostile to their constitution. Beside these general affections, common to the plant and animal, vegetables are injured and often killed, by particular diseases.

Some diseases attack the leaves only, and produce spots of various colours, rugosities, pustules, galls, &c. Others are

peculiar to the flowers and fruit, and often occasion barrenness for a season ; and sometimes this sterility continues during the existence of the plant. Others assault the viscera, or internal organs, and gave rise to obstructions, tumors, and a gradual resolution and corruption of the whole fabrick. Many of the diseases of plants are produced by the insect tribes. Their wounds and depredations are not confined to particular parts, but extend from the root to the stem, branches, leaves, flowers, and fruit. Insects not only injure the substance of plants, but, by feeding on their juices, deprive them of a part of their nourishment, and occasion various diseases or changes in their organization. Other diseases of plants derive their origin from change of climate, from miasmata or noxious vapours in the atmosphere, and from improper culture. When wounded by external injuries, vegetables discharge their blood in copious streams. If the wound be not mortal, the fibres on all sides gradually shoot out and close the fracture by a callous substance.

From this general enumeration, it is obvious, that the diseases of plants are not only similar to those of animals, but proceed from the same causes. In both kingdoms, some diseases are only partial or superficial, and are cured either by Nature, or by the assistance of art. Others are mortal, and succeeded by a total putrefaction or decomposition of the individual.

But, though plants should escape the numberless diseases which daily threaten them, they have no defence against the slow approaches of old age, and its unavoidable consequence, death. In progress of time, the vessels gradually harden and lose their tone. The juices no longer move with equal celerity as in youth. They are not absorbed with the same precision. They at last stagnate and corrupt. This corruption is soon communicated to the vessels in which the juices are contained, and produces a total cessation of all the vital functions.

The life of animals is diversified by a number of successive changes. Infancy, youth, manhood, old age, are characterised by imbecility, beauty, fertility, dotage. All these vicissitudes are conspicuous in the vegetable world. Weak and tender in infancy, beautiful and vigorous in youth, robust and fruitful in manhood, and, when old age approaches, the head droops, the springs of life dry up, and the tottering vegetable, like the animal, returns to that dust from which it sprung.

Upon the whole, by taking a retrospective view of the extreme difficulty of ascertaining the boundaries which distinguish the animal from the vegetable, and of the similarities in their structure and organs, in their growth and nourishment, in their dissemination and decay, it is apparent, that both these kingdoms constitute the same order of beings, and that Nature, in the formation of them, has operated upon one great and common model.

CHAPTER II.

Of the organs and general structure of Animals—A short view of the external and internal parts of the human body—This structure compared with those of Quadrupeds, Birds, Fishes, and Insects—How far peculiarities of structure are connected with peculiarities of manners and dispositions.

IN treating of this subject, it is not intended to dive into the depths of anatomical research. On the contrary, I shall exhibit short views only of the general structure and organization of the various classes of animated beings, from man, who is the most perfect animal of which we have any knowledge, down to the insect tribes. Considering man, therefore, as the standard of animal perfection, we shall institute frequent comparisons, and mark peculiar distinctions between him and the brute creation, both with regard to form, manners and sagacity. By following this plan, I hope I shall be enabled to render a subject which at first sight, may have a forbidding aspect, both interesting and agreeable.

STRUCTURE OF MAN.

The bones may be regarded as the basis upon which the human body is constructed. The spine, or back-bone, consists of a number of vertebrae, or small bones, connected together by cartilages, articulations, and ligaments. In the centre of each vertebrae there is a foreman, or a hole, for the lodgement and continuation of the spinal marrow, which extends from the brain to the rump. From these vertebrae the arched bones called ribs proceed; and seven of them join the breast-bone on each side, where they terminate in cartilages, and form the cavity of the thorax, or chest. This cavity contains the heart and lungs; and the oesophagus, or

gullet, passes through it to reach the stomach. The five lower ribs, with a number of muscles, form another cavity termed the *abdomen*, or belly, in which are contained the stomach, the bowels, the *omentum*, or cawl, the liver, the gall-bladder, the spleen, the pancreas, and the kidneys. The chest and abdomen are separated from each other by the diaphragm, or midriff. The lower part of this last cavity contains the bladder of urine, and the rectum, or termination of the intestines. Beside these, in females, the pelvis includes the uterus and its appendages. This part of the cavity is formed by the *os sacrum*, or termination of the back-bone, and the two *osseae innominatae*.

The bones of the cranium and face are very numerous. They are connected together by means of futures, articulations, and membranes. The bones of the cranium include the brain and its two membranous coverings, called the *pia* and *dura mater*, and the medulla oblongata, of which last the spinal marrow is a prolongation. The bones of the upper and under jaw form another cavity for the reception of the tongue and organs of speech.

The only remaining bones are those of the upper and lower extremities. The shoulder and collar bones articulate with the top of the arm and the breast-bone. The arm-bone, or *os humeri*, is joined to the two bones of the fore-arm, called *ulna* and *radius*, and these last to the bones of the *carpus*, or wrist, by means of articulations and firm membranes. To the bones of the wrist, those of the metacarpus and fingers are attached in a similar manner.

With regard to the lower extremities, the thigh-bone articulates above with the hip-bone, and below with the leg-bone and the rotula, or knee-pan. The leg, like the fore-arm, is composed of two bones, the tibia and fibula, which articulate with each other, and with the tarsal, or heel-bones of the foot; and to these last the metatarsal bones, and those of the toes, are joined.

From this outline, some idea may be formed of the human skeleton. The other parts of which our bodies are composed shall be mentioned in the same cursory manner.

The muscular part of the human fabric consists of numerous bundles of fleshy fibres. Each bundle or distinct muscle, is inclosed in a cellular membrane, by which means they may be raised, or separated from one another by the hand of the anatomist. They are inserted, by strong tendinous extremities, into the different bones of which the skeleton is composed, and, by their contraction and distension, give rise to all the movements of the body. The muscles, therefore, may be considered as so many cords attached to the bones ; and Nature has fixed them according to the most perfect principles of mechanism, so as to produce the fittest motions in the bones or parts for the movement of which they are intended.

The heart is a hollow muscular organ of a conical shape, and consists of four distinct cavities. The two largest are called *ventricles*, and the two smallest *auricles*. The heart is inclosed in the *pericardium*, a membranous bag, which likewise contains a quantity of water, or lymph. This water lubricates the heart, and facilitates all its motions. The heart is the general reservoir of the blood. By the contractions and dilations of this muscle, the blood is alternately thrown out of, and received into, its several cavities. When the heart contracts, the blood is propelled from the right ventricle into the lungs through the pulmonary arteries, which, like all the other arteries, are furnished with valves that play easily forward, but admit not the blood to regurgitate toward the heart. The blood, after circulating through the lungs, returns into the left ventricle of the heart by the pulmonary vein. At the same instant, the left ventricle drives the blood into the aorta, a large artery which sends off branches to supply the head and arms. Another large branch of the

aorta descends along the inside of the back-bone, and detaches numerous ramifications to nourish the viscera and inferior extremities. After serving the most remote extremities of the body, the arteries are converted into veins, which, in their return toward the heart, gradually unite into larger branches, till the whole terminate in one great trunk called the *vena cava*, which discharges itself into the right ventricle of the heart, and completes the circulation.

Beside the heart, the thorax or chest contains the lungs, or organs of respiration. They are divided into five lobes, three of which lie on the right, and two on the left side of the thorax. The substance of the lungs is chiefly composed of infinite ramifications of the trachea or windpipe, which, after gradually becoming more and more minute, terminate in little cells or vesicles, which have a free communication with one another. At each inspiration, these pipes and cells are filled with air, which is again discharged by respiration. In this manner, a circulation of air, which is necessary to the existence of men and other animals, is constantly kept up as long as life remains.

The instruments and process of digestion fall next to be considered. The stomach is a membranous and muscular bag furnished with two orifices : By the one it has a communication with the *oesophagus*, or gullet, and by the other with the bowels, which begin at the stomach and terminate at the anus. In the stomach and intestines there are immense numbers of minute vessels called *lacæals*, the mouths of which are constantly open for the reception of the nutritious particles. After being moistened and lubricated by the saliva, the food is received into the stomach, where it is still farther diluted by the gastric juice, which has the power of dissolving every kind of animal and vegetable substance. When the food has remained some time in the stomach, it is reduced to a grayish pulp, mixed with some chylous or

milky particles. The thinner and more perfectly digested parts of the food gradually pass through the *pylorus*, or lower aperture of the stomach, into the intestines, where they are still farther attenuated and digested by the bile and pancreatic juices. While the food is in this fluid state, it receives the denomination of *chyle*, and is continually absorbed by the mouths of the lacteal veins. These vessels arise, like network, from the inner service of the intestines, pass obliquely through their coats, and, running along the mesentery, unite, as they advance, into larger branches, and at last terminate in the thoracic duct, or general receptacle of the chyle. Beside the lacteals, there is another system of vessels called *lymphatic*, or absorbent veins : They are minute pellucid tubes, and generally lie close to the large blood-vessels. The lymphatics from all the lower parts of the body gradually unite as they approach the thoracic duct, into which they pour a colourless fluid by three or four large trunks ; and the lymphatics from all the superior parts of the body likewise discharge their lymph into the same duct as it runs upward to terminate in the left subclavian vein. By this curious and beautiful machinery, the chyle and lymph, which consist of the nutritious matters extracted from the food, enter the circulating system, are converted into blood, and afford that constant supply of nourishment which the perpetual waste of our bodies demands.

We shall next give a sketch of those important organs by which we are enabled to multiply and continue the species. The circulation of the blood, and the mode by which the quantity of it is continually kept up by fresh supplies of chyle, are effects which, in some measure, correspond with our ideas of the machinery employed. The organs of generation exhibit a still more complex specimen of exquisite mechanism. But the machinery employed, without the aid of experience, could never suggest the most distant idea of the effect to be produced.

In the male, the organs of generation consist of the testes, the seminal vessels, and the penis. The testes are two glandular bodies which possess the power of converting the blood into semen. They are originally formed and lodged in the abdomen ; and it is not till after birth that they commonly pass into the groin, and from thence fall into the scrotum, which is a muscular bag prepared for their reception and defence. The testes of the hedgehog and of some other quadrupeds remain in the abdomen during life. Instances of the same kind sometimes happen in the human species. Each testicle is composed of the spermatic artery and vein. The blood passes very slowly through the spermatic artery, and produces an infinite number of convolutions in the substance of the testicle, where it deposits the semen, which is taken up by the semeniferous tubes. These tubes at length unite, and, by an immense number of circumvolutions, form a kind of appendix to the testicle, commonly known by the term *epididymis*. The tubes of the epididymis, after terminating in an excretory duct called *vas deferens*, ascend toward the abdominal rings, and deposit the semen in the seminal vesicles, which are two soft convoluted bodies situated between the rectum and bladder, and unite at their lower extremity : From these reservoirs the semen is occasionally discharged through the short canals which open into the urethra. The penis is a cavernous and spungy substance perforated longitudinally by a canal called *urethra*, which, by communicating with the bladder and seminal vessels, answers the double purpose of discharging both the urine and semen.

With regard to the female organs, the uterus and its appendages merit a principal attention. The uterus is a hollow muscular body situated between the rectum and bladder, and, when not in an impregnated state, resembles a pear, with the thickest end turned toward the abdomen. The en-

trance into the cavity of the uterus forms a small protuberance, which has been compared to the mouth of a tench, and from this circumstance it has received the name of *os tincae*. The uterus is connected to the sides of the pelvis by two broad ligaments, which support it in the vagina in a pendulous situation. From each side of the bottom of the uterus the two Fallopian tubes arise, pass through the substance of the uterus, and extend along the broad ligaments till they reach the edge of the pelvis ; from whence they are reflected backward, and turning over behind the ligaments, their extremities hang loose in the pelvis. These extremities, because they have a ragged appearance, are called *fimbriae*, or *morsus diaboli* : Each Fallopian tube is about three inches long. Their cavities are at first very small, but become gradually larger, like a trumpet, as they approach the fimbriae. Near the fimbriae of each tube, about an inch from the uterus, are situated the ovaria, or two oval bodies, about half the size of the male testicle. They are covered with a production of the peritoneum, and hang loose in the pelvis. In their substance there are several minute vesicles filled with lymph. The number of these vesicles seldom exceeds twelve in each ovary. In mature females, these vesicles become exceedingly turgid ; and a yellow coagulum gradually forms in one of them, which increases till its coat disappears. It then changes into a hemispherical body called *corpus luteum*, which is described as being hollow and containing within its cavity very minute eggs, each of which, it is supposed, may be impregnated, and produce a foetus. After impregnation, one of these eggs, as we are informed by anatomists, is absorbed by and passes through the Fallopian tube into the uterus, where it is nourished till mature for birth.

We shall conclude this subject with a concise account of the instruments of sensation. The organs hitherto described convey nothing more than the idea of an automaton, or self-

moving machine. But sensation, or the perception of pleasure and pain, is effected by organs of a peculiar kind. These organs are all comprehended under the general appellation of the *brain* and *nerves*.

Beside the bones of the cranium, the brain is invested with two membranes, called *dura* and *pia mater*, because they were supposed by the Arabians to be the source of all the other membranes of the body. Under the denomination of *brain* are comprehended three distinct parts, the *cerebrum*, the *cerebellum*, and *medulla oblongata*. The *cerebrum* is a soft medullary mass, situated in the anterior part of the skull, and divided, by a portion of the *dura mater*, into two hemispheres. It consists of two substances, the cortical, which is greyish, and the medullary, which is softer, and of a very white colour. The *cerebellum* is divided into two lobes, and its substance is firmer and more compact than that of the *cerebrum*. It is likewise composed of the cortical and medullary substances. The reunion of the medullary substances of the *cerebrum* and *cerebellum*, at the basis of the skull, forms the *medulla oblongata*, of which the spinal marrow is a continuation. The brain of the human species is proportionally much larger than that of quadrupeds.

The brain and spinal marrow are supposed to be the origin of all the nerves or instruments of sensation. The nerves are, in general, cineritious, shining, inelastic cords. But they differ from each other in size, colour, and consistence. From numberless experiments and observations, it is unquestionable, that the nerves are the instruments both of sensation and of animal motion. But, how these effects are produced by the nervous influence is a discovery still to be made. The inquiry, however, has given rise to several ingenious conjectures and hypotheses. Some physiologists have maintained, that the nerves are solid cords, which may be divided into an infinite number of minute filaments; and that, by

the vibrations of these cords, the various impressions and modifications of feeling are conveyed to the brain. Others, with more plausibility, have supposed, that the nerves are assemblages of small tubes; that a subtle fluid, sometimes called *animal spirits*, is secreted in the brain and spinal marrow; and that by the influence or motions of this fluid all the sensations of animals are transmitted to the sensorium, or general repository of ideas. But it is needless to dwell upon a subject covered with darkness, and which all the efforts of human powers will probably never bring to light.

Anatomists have described forty pair of nerves. Ten of them proceed from the medulla oblongata of the brain, and thirty from the spinal marrow. These nerves, by sending off innumerable ramifications, are distributed, like a network, over every part of the body, till they terminate, in the form of a minute papillae, upon the skin. That the nerves are the immediate instruments of sensation, as well as of muscular motion, has been proved by a thousand uncontrollable experiments. When the trunk of the sciatic nerve is cut, the thigh and leg on that side instantly lose all motion, and all sense of pain, below the incision, and neither time nor art can ever restore the power of feeling or of moving. But the parts between the incision and the spinal marrow, which is a continuation of the brain, retain their usual degrees both of motion and of sensation. From this experiment, it is evident, that the nerves are the organs by which sensation and motion are effected, and that, for these important purposes, an uninterrupted connection between any particular nerve and the brain, or spinal marrow, is indispensable.

This sketch of the human fabric requires an apology to anatomical readers, who must be sensible of its many imperfections. To persons who have not studied that curious and useful science, I imagined a general view of the structure of

man, if properly composed, might enable them to acquire more distinct ideas of the many seeming deviations from the common plan observed by Nature in the formation of the inferior and more imperfect animals.

OF THE STRUCTURE OF QUADRUPEDS.

Having delineated the structure and organs of the human species, it is worthy of remark, that the intellect, or sagacity, of inferior animals augments or diminishes in proportion as the formation of their bodies approaches to, or recedes from, that of man. Quadrupeds, accordingly, are more intelligent than birds ; the sagacity of birds exceeds that of fishes ; and the dexterity and cunning of fishes are superior to those of most of the insect tribes. The same gradation of mental powers is exhibited in different species of the same classes of animals. The form of the ourang outang makes the nearest approach to the human ; and the arts he employs for his defence, the actions he performs, and the sagacity he discovers, are so astonishing, that some philosophers have considered him as a real human being in the most debased stage of society. Next to the ourang outang, the organs of the different species of apes and monkeys have the greatest resemblance to those of man ; and their powers of imitation, their address in procuring their food, and in managing their young, their ingenuity, and their sagacious manners, have contributed to the amusement, and excited the admiration of mankind in all ages and nations. The same relation between form and intellect may be traced in the dog, the cat, the sow, the horse, the sheep, and the other species of quadrupeds.

With regard to the general structure and figure of quadrupeds, a great variety is exhibited in the different kinds. But when examined in detail, it is apparent, that they, as well as man, are all formed upon one primitive and general

design. Beside the organs of tension, of circulation, of digestion, and of generation, without which most animals could neither subsist nor multiply, there is, even among those parts that chiefly contribute to variety in external form, such a wonderful resemblance as necessarily conveys the idea of an original plan upon which the whole has been executed. For example, when the parts constituting a horse are compared with the human frame, instead of being struck with their difference, we are astonished at their singular and almost perfect resemblance. Take the skeleton of a man, says Buffon, incline the bones of the pelvis; shorten those of the thighs, legs, and arms; join the phalanges of the fingers and toes; lengthen the jaws by shortening the frontal bones; and, lastly, extend the spine of the back. This skeleton would no longer represent that of a man; It would be the skeleton of a horse. For, by lengthening the back-bone and the jaws, the number of the vertebrae, ribs, and teeth, would be increased; and it is only by the number of these bones, and by the prolongation, contraction, and junction of others, that the skeleton of a horse differs from that of a man. The ribs, which are essential to the figure of animals, are found equally in man, in quadrupeds, in birds, in fishes, and even in the turtle. The foot of the horse, so apparently different from the hand of a man, is composed of similar bones; and, at the extremity of each finger, we have the same small bone, resembling the shoe of a horse, which bounds the foot of that animal. Raise the skeletons of quadrupeds, from the ape-kind to the mouse, upon their hind-legs, and compare them with the skeleton of a man, the mind will be instantly struck with the uniformity of structure and design observed in the formation of the whole group. This uniformity is so constant, and the gradations from one species to another are so imperceptible, that to discover the marks of their discrimination requires the most minute attention. Even the bones of the tail will make but a slight impression on the observer.

The tail is only a prolongation of the *os coccygis*, or rump-bone, which is short in man. The orang outang, and true apes, have no tail ; and, in the baboons, and several other quadrupeds, the tail is exceedingly short. Thus, in the creation of animals, the Supreme Being seems to have employed only one great idea, and, at the same time, to have diversified it in every possible manner, that men might have an opportunity of admiring equally the magnificence of the execution and the simplicity of the design.

In quadrupeds, as well as in man, the bones are connected by articulations and membranes ; and the different movements of these bones are performed by the operation of muscles. The number, disposition, and form of the muscles with a few exceptions arising from the figure and destination of parts peculiar to particular animals, are nearly the same in men and in quadrupeds. The circulation of their blood, the secretion of their fluids, and the process of digestion, are carried on by organs perfectly similar to those of the human body. In the external covering, a small difference takes place. Quadrupeds are furnished with a thick covering of hair, or wool, to defend them from the injuries of the weather. Being destitute of art sufficient to make garments, Nature has supplied that defect, by giving them a coat of hair, which varies in thickness according to the season of the year and the difference of climate. In Russia, Lapland, Kamtschatka, and all the northern regions, the furs of animals are very thick and warm. But, in Turkey, Africa, and the southern parts of Asia and America, most quadrupeds are thinly clad, and some of them, as the Turkish dog, are totally destitute of hair.

The skin of quadrupeds is disposed nearly in the same manner as the human, only it is more elastic. Immediately under the skin, there is a thin muscular substance, called *pannulus carnosus*, which is common to all quadrupeds, except the

hog and armadillo kinds. This substance, which is peculiar to quadrupeds, chiefly covers the trunk, and, by suddenly shaking and shrivelling the skin, enables these animals to drive off insects, or other offensive bodies.

The substance of the nerves, or organs of sensation, is the same in the quadruped and in man. They originate from the brain and spinal marrow, and are distributed over all the internal and external parts of the body, in the same manner as in the human frame.

Thus it appears, that, in general structure and organization, the brute creation is nearly allied to the human species. Some differences, however, merit attention ; because a slight variation in structure, especially of the internal organs, is often accompanied with great diversities in dispositions, food, and manners.

Some animals feed upon flesh, others upon vegetables, and others upon a mixture of both. The dispositions of some species are fierce ; and their manners convey to us the ideas of cruelty and of barbarism ; the dispositions and manners of other species are soft and placid, and excite in us ideas of mildness, complacency, and innocence. The ferocity of the tyger and hyaena forms a perfect contrast to the gentleness and inoffensive behaviour of the sheep and the ox. This opposition of manners has given rise to the distinction of animals into rapacious and mild, carnivorous and herbivorous. In the structure of these animals, whose characters are so opposite, some differences have been discovered, which indicate the intentions of Nature in forming them, and fully justify the seeming cruelty of their conduct.

In all the carnivorous tribes, the stomach is proportionally smaller, and the intestines shorter, than in those animals which feed upon vegetables. As animals of the former kind live solely on flesh, the shortness and narrowness of their intestines are accommodated to the nature of their food. Ani-

mal food is more easily reduced to chyle, and becomes sooner putrid, than vegetable. Of course, if its juices were allowed to remain long in the intestines, instead of nourishing the body, they would produce the most fatal distempers. Beside this accommodation of the intestines to the nature of their food, carnivorous animals are furnished with the necessary instruments for seizing and devouring their prey. Their heads are roundish, their jaws strong, and their tusks very long and sharp. Some of them, as the lion, the tyger, and the whole cat-kind, are provided with long retractile claws. Thus both the internal and external structure of this class of animals indicate their destination and manners. The rapid digestion of their food is a consequence of the strength and shortness of their intestines ; and the intolerable cravings of their appetite necessarily create a fierceness and rapacity of disposition. Nothing less than blood can satiate them. Their cruelty, and the devastation they make among the weaker and more timid tribes, are effects resulting solely from the structure and organs with which Nature has thought proper to endow them. Hence, if there be any thing reprehensible in the manners and dispositions of carnivorous animals, Nature alone is to blame ; for all their actions are determined by the irresistible impulses of their organization. But, even in this seemingly cruel arrangement, Nature must not be rashly accused. When we come to treat of the hostilities of animals, I hope to be able to show, that Nature, in the formation of rapacious creatures, has acted with her usual wisdom, and that beings of this kind have their uses in the general system and œconomy of the universe.

As to the herbivorous tribes, or those animals which feed upon grain and herbage, a slight variation of organs produces the greatest effects upon their disposition and manners. The intestines of this tribe are very long, capacious, and convoluted. Vegetable food, especially herbage, contains a smaller quan-

tity of nutritive matter than the flesh of animals ; neither is it so easily reduced to chyle. A large quantity, therefore, as well as a longer detention in the stomach and intestines, is necessary for the nourishment of these creatures. Several quadrupeds comprehended under this order ruminate or chew the cud. These are furnished with no less than four stomachs. The food after mastication, is thrown into the first stomach, where it remains some time ; after which, the animal forces it up again into the mouth, and gives it a second chewing. It is then sent directly into the second stomach, and gradually passes into the third and fourth ; and, lastly, it is transmitted through the convolutions of the intestines, and the dregs, or faeces, are thrown out of the body. By this machinery, herbivorous animals are enabled to devour large quantities of vegetable aliment, to retain it long in their bowels, and consequently to extract from it nutritive matter sufficient for their growth, support, and multiplication. Here the quantity compensates the quality of the nutriment.

It is true, that the horse, the ass, the hare, and some other animals which live upon herbage and grain, have only one stomach. But, though the horse and ass have one stomach only, their intestines are furnished with sacs or pouches so large, that they may be compared to the paunch of ruminating animals ; and hares, rabbits, the Guiney-pig, &c. have blind guts so long and capacious, that they are equivalent to a second stomach. The hedgehog, the wild boar, the squirrel, &c. whose stomach and intestines are of a mean capacity, eat little herbage, but live chiefly upon seeds, fruits, and roots, which contain, in small bounds, a greater quantity of nutritive matter than the leaves or stems of plants.

The external form of herbivorous animals, like that of the rapacious, is accommodated to their dispositions and the oeconomy they are obliged to observe. That they might be

enabled to reach the surface of the earth with ease, the legs of the larger kinds are proportionally short ; their head and neck long ; and the muscles and tendons of the neck are endowed with prodigious strength. Without these peculiarities of structure, they could not support the prone posture of the head in the tedious operation of browsing large quantities of herbage. The arrangement and form of their teeth likewise indicate the destination of the ruminating tribes. They have no cutting teeth in the upper jaw ; and they are totally deprived of tusks, or canine teeth. This last circumstance, joined to their want of claws, shews that they are not intended to prey upon other animals. Horns are the only weapons of defence with which they are provided. From the nature of their food, therefore, and the internal and external configuration of their bodies, it is evident, that animals of this description must be humble in their deportment and mild in their disposition. This order of animals, accordingly, have uniformly been celebrated for gentleness of manners, submission, and timidity. Man has availed himself of those dispositions, by reducing almost the whole of this tribe to a domestic state. But, in all this graciousness of aspect and tractability of temper, the animals themselves have no merit. Their motions and actions are necessary results of the organs which Nature has bestowed on them. It is obvious, therefore, that the diversity of tastes and dispositions exhibited by different animals, arises not solely from any superior agreeableness of particular kinds of food to their palates, or to a peculiar bias of their minds to benevolence and peace, but from a physical cause depending on the structure of their bodies.

From what has been advanced, it follows, that man, whose stomach and intestines are proportionally of no great capacity, could not live upon herbage alone. It is an incontestible fact, however, that he can live tolerably well upon bread, herbs, and the fruits, roots, and seeds of plants ; for we know

whole nations, as well as particular orders of men, who are prohibited by their religion from eating any animal substance. But these examples are not sufficient to convince us, that the health, vigour, and multiplication of mankind would be improved by feeding solely upon pot-herbs and bread. Besides, his stomach and intestines are of a mean capacity between those of the carnivorous and herbivorous animals. From this circumstance alone we are warranted to conclude, that Nature intended him to feed partly on animal and partly on vegetable substances; and daily experience teaches us, that men fed in this manner are larger, stronger, and more prolific, than those who are confined to a vegetable diet. If man had no other sources of superiority over the other animals than those which originate from the structure of his body, his dispositions ought to be a medium between those of the carnivorous and herbivorous tribes. When considered merely as an animal, this appears to be really the case. Vulgar and uninformed men, when pampered with a variety of animal food, are much more choleric, fierce, and cruel in their tempers than those who live chiefly on vegetables. Animal food heats the blood, and makes it circulate with rapidity. In this situation, every object capable of exciting appetite or passion operates with redoubled force. The weak mind yields to the impulse, and gives vent to every species of outrage which can debase human nature.

In the formation of his body, man has some advantages over particular animals. But these advantages are inconsiderable, and none of them, perhaps, are peculiar to the species. The structure of all animals is nicely adjusted to their destination, and the station they occupy in the general scale of Being. The body of man is erect, and his attitude is said to be that of command. His majestic deportment, and the firmness of his movements, announce the superiority of his rank. His arms are not mere pillars for the support of his

body. His hands tread not the earth ; neither do they lose, by friction and pressure, that exquisite delicacy of feeling for which Nature had originally intended them. His arms and hands, on the contrary, are formed for purposes of a more noble kind. They are destined for executing the commands of his will, for laying hold of bodies, for removing obstacles, for defending him from injuries, and for seizing and retaining objects of pleasure. The features of this picture are exact delineations ; but they are not the exclusive privilege of man. The orang outang walks erect, and he derives equal advantages from his hands and arms as the human species. Some apes have likewise the power of walking erect, with the additional faculty of employing their hands and arms as legs. They can walk, run, or leap, by the instrumentality either of two or of four extremities, as their situation or necessities may require. It is not, therefore, the fabric of man's body that entitles him to claim a superiority over the other animals. The formation of their bodies is adjusted with equal symmetry and perfection to the rank they hold in the general system of animation. Many of them excel us in magnitude, strength, swiftness, and dexterity in particular movements. Their senses are often more acute ; they seize their prey, or procure herbage, fruits, and seeds of trees, with more facility than man, when limited to the powers of his animal nature. Hence the great source of man's superiority over the brute creation must be derived from his mental faculties alone. Brutes enjoy the same instincts, the same appetites, and the same propensities, as appear in the constitution of the human mind. But the instincts of brutes, though they are exerted with great certainty and precision, are much circumscribed with regard to extension and improvement. Like man, they derive advantages from experience. But the conclusions they draw from this source are always feeble and extremely limited. Neither

do they possess the inestimable faculty of transmitting the knowledge acquired by individuals from generation to generation. By means of their senses, they learn to distinguish their enemies, or hurtful objects, at a distance ; and they know how to avoid them. Experience teaches them to discriminate objects of pleasure from those of pain ; and they act according to the feelings excited by these objects. Some animals can even accommodate their instincts to particular circumstances and situations. The feelings of brutes are often more exquisite than ours. They have sensations ; but their faculty of comparing them, or of forming ideas, is much circumscribed. A dog or a monkey can imitate some human actions, and are capable of receiving a certain degree of instruction. But their progress soon stops : Nature has fixed the boundaries of mental as well as of corporeal powers ; and these boundaries are as various as the number of distinct species. Our wonder is equally excited by the sagacity of some animals, and by the stupidity of others. This gradation of mental faculties originates from the number or paucity of instincts bestowed on particular species, joined to the greater or smaller power of extending or modifying these instincts by experience and observation. Man is endowed with a greater number of instincts than any other animal. The superiority of his rank, however, does not proceed from this source alone. Man enjoys beyond every other animal the faculty of extending, improving, and modifying the different instincts he has received from Nature. It is this faculty which enables him to compare his feelings, to form ideas, and to reason concerning both. The bee makes cells, and the beaver constructs habitations of clay. The order of their architecture, however, is invariably the same. Man likewise builds houses : But he is not forced, by an irresistible instinct, to work always on the same plan. His habitations, on the contrary, vary with the fancy of the individuals who design and construct them.

Upon the whole, the dignity of man's rank depends not upon the structure of his organs. It is from the powers of his intellect alone that he is entitled to claim a superiority over the brute creation. These powers enable him to form ideas, to abstract, to reason, to invent, and to reach all the heights of science and of art.

The remarks formerly made are applicable to quadrupeds in general. But, before concluding this branch of the subject, we shall point out a few peculiarities in the structure of particular species.

Beside the four stomachs common to ruminating animals, the camel and dromedary have a fifth bag, which serves them as a reservoir for holding water. This bag is capable of containing a very large quantity of that necessary element. When the camel is thirsty, and has occasion to macerate his dry food in the operation of ruminating, by a simple contraction of certain muscles, he makes part of this water ascend into his stomach, or even as high as the gullet. This singular construction enables him to travel six, eight, or even twelve days in the sandy deserts, without drinking, and to take at once a prodigious quantity of water, which remains in the reservoir pure and limpid; because neither the humours of the body, nor the juices that promote digestion, can have access to it. Beside this singularity of structure, the camel has two large fleshy bunches on his back, and the dromedary, or swift camel, one bunch; and the feet of both are covered with a very tough, but flexible substance. The conformation of these animals enables them to travel with heavy loads through the sandy deserts of the East, where the horse or the ass would inevitably perish; because Nature has not provided them with reservoirs for holding and preserving water, which are indispensable in countries where none of that element can be procured but in particular places, that are often distant many days journey from

each other. When we consider the structure of the camel and dromedary, we cannot be deceived with regard to their destination. The four stomachs indicate a vegetable diet, and the same docility and gentleness of manners which characterise the whole ruminating tribes. From the addition of a fifth bag, or reservoir for the reception and preservation of water, we should expect to find some peculiarity of disposition. In this conjecture we are not deceived. Of all animals which man has subjugated, the camel and dromedary are the most abject slaves. With incredible patience and submission they traverse the burning sands of Africa and Arabia, carrying burdens of amazing weight. Instead of discovering symptoms of reluctance, they spontaneously lie down on their knees till their master binds the unmerciful load. Arabia, and some parts of Africa, are the driest and most barren countries in the world. Both the constitution and structure of camels are nicely adapted to the soil and climate in which they are produced. The Arabians consider the camel as a gift sent from heaven, a sacred animal, without whose assistance they could neither subsist, traffick, nor travel. The milk of the camel is their common food. They also eat its flesh ; and of its hair they make garments. In possession of their camels, the Arabs want nothing, and have nothing to fear. In one day they can perform a journey of fifty leagues into the desert, which cuts off every approach from their enemies. All the armies in the world would perish in pursuit of a troop of Arabs. An Arab, by the assistance of his camel, surmounts all the difficulties of a country which is neither covered with verdure, nor supplied with water. Notwithstanding the vigilance of his neighbours, and the superiority of their strength, he eludes their pursuit, and carries off, with impunity, all that he ravages from them. When about to undertake a predatory expedition, an Arab makes his camels carry both his and their

own provisions. When he reaches the confines of the desert, he robs the first passengers who come in his way, pillages the solitary houses, loads his camels with the booty, and, if pursued, he accelerates his retreat. On these occasions he displays his own talents as well as those of his camels. He mounts one of the fleetest, conducts the troop, and obliges them to travel day and night, without almost either stopping, eating, or drinking ; and, in this manner, he often performs a journey of 300 leagues in eight days.

Another order of quadrupeds deserves our notice. Those which have been distinguished by the appellation of amphibious, are capable of remaining a long time under water. They live chiefly upon fishes, and, without this faculty of continuing a considerable time under water, they would be unable to procure their food. To this tribe belong the seal, the walrus, the manati, the sea-lion, &c. The seal and walrus are more nearly allied to land-quadrupeds than to the cetaceous animals ; because they have four distinct legs, though nothing but the feet project beyond the skin. The toes of the feet are all connected by membranes, which enable these animals to swim in quest of their prey. They differ from terrestrial quadrupeds by the singular faculty of living with equal ease either in air or in water. This peculiarity of economy and manners presupposes the necessity of some deviation from the general structure of quadrupeds ; and Nature has accomplished this purpose by a very simple artifice.

In man, and in all land-quadrupeds, the lungs of the foetus have no motion, and receive no more blood than is requisite for their growth and nourishment. But, immediately after birth, the young animals respire, and the whole mass of blood circulates through their lungs. To carry on the circulation in the foetus state, another passage was necessary. The blood in the right auricle of the heart, instead of passing

into the pulmonary artery, and, after circulating through the lungs, returning into the left auricle by the pulmonary vein, passes directly from the right to the left auricle through an aperture called the *foramen ovale*, which is situated in the partition of the heart that separates the cavities of the two auricles. By this contrivance, the mass of blood, without deviating into the lungs, enters the aorta, and is distributed over every part of the body. In man, and the other terrestrial animals, the *foramen ovale* of the heart, which permits the foetus to live without respiration, closes the moment after birth, and remains shut during life. Animals of this construction can neither live without air, nor remain long under water without being suffocated.

But, in the seal, walrus, and other amphibious animals, the *foramen ovale* continues open during life, though the mothers bring forth on land, and respiration commences immediately after birth. By means of this perpetual aperture in the septum or partition of the heart, which allows a direct communication of the blood from the *vena cava* to the *aorta*, these animals enjoy the privilege of respiring, or not, at their pleasure.

This singularity in the structure of the heart, and the consequent capacity of living equally on land and in water, must necessarily produce some peculiarities in the manners and dispositions of amphibious animals. The seal, accordingly, whose history is best known, may be considered as holding the empire of the silent ocean. To this dignity he is entitled by his voice, his figure, and his intelligence, which render him so superior to the fishes, that they seem to belong to another order of beings. Though his oeconomy be very different from that of our domestic animals, he is susceptible of a species of education. He is reared by putting him frequently in water. He is taught to give a salute with his head and his voice. He approaches when called upon. His

fenses are equally acute as those of any quadruped ; and, of course, his sensations and intellect are equally active. Both are exhibited in the gentleness of his manners, his social disposition, his affection for the female, his anxious attention to his offspring, and the expressive modulation of his voice. Besides, he enjoys advantages which are peculiar to him. He is neither afraid of cold nor of heat. He lives indifferently on herbs, flesh, or fish. He inhabits, without inconvenience, water, land, or ice. When assistance is necessary, the seals understand and mutually assist one another. The young distinguish their mother in the midst of a numerous troop. They know her voice ; and, when she calls, they never fail to obey.

Before dismissing this branch of the subject, the elephant must not be passed over in silence. His structure is uncommon, and so are his talents. The elephant is the largest and most magnificent animal that at present treads the earth. Though he daily devours great quantities of herbage, leaves, and branches of trees, he has but one stomach, and does not ruminant. This want, however, is supplied by the magnitude and length of his intestines, and particularly of the colon, which is two or three feet in diameter by fifteen or twenty in length. In proportion to the size of the elephant, his eyes are very small ; but they are lively, brilliant, and capable of a pathetic expression of sentiment. He turns them slowly, and with mildness, towards his master. When he speaks, the animal regards him with an eye of friendship and attention. He seems to reflect with deliberation, and never determines till he has examined, without passion or precipitation, the orders which he is desired to obey. The dog, whose eyes are very expressive, is too prompt and vivacious to allow us to distinguish with ease the successive shades of his sensations. But, as the elephant is naturally grave and moderate, we perceive in his eyes the order and succession of

his thoughts. His ears are very large, and much longer, even in proportion to his body, than those of the ass. They lie flat on the head, and are commonly pendulous ; but he can raise and move them with such facility, that he uses them as a fan to cool himself, and to defend his eyes from dust and insects. His ear is likewise remarkably fine ; for he delights in the sound of musical instruments, and moves in cadence to the trumpet and tabour.

But, in the structure of the elephant, the most singular organ is his trunk or proboscis. It is composed of membranes, nerves, and muscles ; and it is at once an instrument of feeling and of motion. The animal can not only move and bend the trunk, but he can contract, lengthen, and turn it on all sides. The extremity of the trunk terminates in a protuberance that stretches out on the upper side in the form of a finger ; by means of which he lifts from the ground the smallest pieces of money ; he selects herbs and flowers, and picks them up one by one ; he unties the knots of ropes, opens and shuts gates by turning the keys or pushing back the bolts. In the middle of the protuberance or finger, there is a cavity in the form of a cup, and, in the bottom of the cup are the apertures of the two organs of smelling and respiration. This hand of the elephant possesses several advantages over that of the human. It is more flexible, and equally dexterous in laying hold of objects. Besides, he has his nose in his hand, and is enabled to combine the power of his lungs with the action of his finger, and to attract fluids by a strong suction, or to raise heavy bodies by applying to them the edge of his trunk, and making a vacuum within by a vigorous inspiration. Hence delicacy of feeling, acuteness of smelling, facility of movement, and the power of suction, are united at the extremity of the elephant's trunk. Of all the instruments which Nature has bestowed on her most favourite productions, the trunk of the elephant seems to be

the most complete, as well as the most admirable. It is not only an organic instrument, but a triple sense, whose united functions exhibit the effects of that wonderful sagacity which exalts the elephant above all other quadrupeds. He is not so subject, as some other animals, to errors of vision ; because he quickly rectifies them by the sense of touch ; and, by using his trunk as a long arm, for the purpose of touching remote objects, he acquires, like man, clear ideas of distances. But other animals, except such as have a kind of arms and hands, can only acquire ideas of distances by traversing space with their bodies. Delicacy of feeling, the flexibility of the trunk, the power of suction, the sense of smelling, and the length of the arm, convey ideas of the substance of bodies, of their external form, of their weight, of their salutary or noxious qualities, and of their distances. Thus, by the same organs, and by a simultaneous act, the elephant feels, perceives, and judges of several things at one time. It is by virtue of this combination of senses and faculties in the trunk that the elephant is enabled to perform so many wonderful actions, notwithstanding the enormity of his mass and the disproportions of his form. The thickness and rigidity of his body ; the shortness and stiffness of his neck ; the smallness of his head ; the largeness of his ears, nose, and tusks ; the minuteness of his eyes, mouth, genitals, and tail ; his straight, clumsy, and almost inflexible limbs ; the shortness and smallness of his feet ; the thickness and callosity of his skin ; all these deformities are the more obvious and disagreeable, because they are modelled on a large scale, and most of them are peculiar to the elephant.

From this singular conformation, the animal is subjected to many inconveniences. He moves his head with difficulty, and cannot turn back without making a large circuit. For this reason, the hunters attack him behind, or on

the flanks, and avoid the effects of his rage by circular movements. He cannot seize any object on the ground with his mouth, because his neck is too stiff to allow his head to reach the earth. He is therefore obliged to lay hold of his food, and even of his drink, with his nose, and then convey them to his mouth. It is likewise a consequence of this structure, that the young elephants are said to suck with their nose, and afterwards pour the milk into their gullet.

OF THE STRUCTURE OF BIRDS.

From the figure and movements of the feathered tribes, we should be led to imagine that the structure of their organs was extremely different from that of quadrupeds. Their oeconomy and manner of living required some variations in their frame. But those variations are by no means so many or so great as might be expected. Instead of hairs, their bodies are covered with feathers, which, beside the beautiful variety of their colours, protect this class of animals from the assaults of rain and cold. They have only a couple of legs ; but Nature has furnished them with two additional instruments of motion, by which they are enabled to rise from the surface of the earth, and to fly with amazing rapidity through the air. The wings are articulated with the breast-bone, and their motions are performed by muscles of remarkable strength. Many birds are continually passing through hedges and thickets. To defend their eyes, therefore, from external injuries, as well as from too much light when flying in opposition to the rays of the sun, they are furnished with a membrane called *membrana nictitans*, which, like a curtain, can at pleasure be drawn over the whole eye. This covering is neither opaque nor pellucid ; but, being somewhat transparent, it allows as many rays to enter as render any object just visible, and enable them to direct their

progress through the air. It is by the instrumentality of this membrane that the eagle looks at the sun. The feathers of all birds are inserted into the skin in such a manner that they naturally lie backward from the head ; and allow the rain to run off their bodies, and, by turning their heads in opposition to the wind, prevent the wind from rumpling their feathers and retarding their flight. Beside this provision, the rump of birds terminates in a large gland, which secretes an oily substance. When the feathers are too dry, or any way disordered, the animals squeeze this gland with their bills, extract the oil, and with it they besmear and dress the feathers. By this means the admission of water is totally prevented. Birds have no separate ribs ; but the breast-bone, which is very large, joins the back-bone, and supplies their place.

With regard to the external figure of birds, the form of their bodies is nicely adapted to their manners and the mode of life they are destined to pursue. By striking the air with their wings, they move forward in that element, and their tail serves them as a rudder to direct their course. Their breast-bone, instead of being flat, rises gradually from the spine and terminates in a sharp ridge or keel, which enables them to cut the air with greater facility. For the same purpose, the heads of birds are proportionally smaller than those of quadrupeds, and most of them terminate in light sharp-pointed beaks. They are likewise deprived of external ears, and of protuberant nostrils. Their tails, instead of vertebrae, muscles, and skin, consist entirely of feathers. They have no pendulous scrotum, no bladder, no fleshy uterus. Neither have they an epiglottis, though many of them possess great powers of modulation, and some of them may even be taught to articulate words. To lighten their beaks, they are deprived of lips and teeth ; and their abdomen or belly is proportionally small and narrow.

From this general view of the external figure and structure of birds, it is apparent, that Nature has designed them for two distinct kinds of motion. They can, at pleasure, either walk on the surface of the earth, or mount aloft, and penetrate the airy regions with prodigious swiftness.

Some peculiarities in the internal structure of birds deserve our notice.

Like quadrupeds, the feathered tribes are divided into granivorous and carnivorous ; and their manners and dispositions correspond with their internal and external conformation.

In the granivorous class, the oesophagus or gullet runs down the neck, and terminates in a pretty large membranous sac, called the *ingluvies*, or craw, where the food is macerated, and partly dissolved by a liquor secreted from glands spread over the surface of this sac. Some birds, as the rooks and the pigeon kind, have the power of bringing up the food from this sac into their mouths, and feeding their young with it in a half digested form. After macerating for some time, the food passes through the remainder of the gullet into another species of stomach denominated *ventriculus succenturiatus*, which is a continuation of the gullet. Here the food receives a farther dilution. From this second stomach, the food is transmitted to the gizzard, or true stomach, which consists of two very strong muscles, covered externally with a tendinous substance, and lined with a thick firm membrane. The remarkable strength of the gizzard was formerly supposed to assist the digestion of granivorous birds by attrition. But this notion has of late been entirely exploded ; for Doctor Stevens, and, after him, Spalanzani, have demonstrated, by unequivocal experiments, that digestion is performed solely by the dissolving powers of the gastric juices.* The other intestines are proportionally larger, and much longer than those of the carnivorous birds.

See Stevens Dissert. Med. Inaug. De Alimentorum Concoctione, Edin. 1777, and Spalanzani.

The structure of the heart, in granivorous birds, is nearly the same with that of quadrupeds.

The lungs hang not loose in the cavity of the thorax, but are fixed to the back-bone : Neither are they divided into lobes, as in man and other animals whose spines admit of considerable motion. They are red, spongy bodies, covered with a membrane that is pervious, and communicates with the large vesicles or air-bags which are spread over the whole abdomen. These vesicles, when distended with air, render the bodies of birds specifically light. They likewise supply the place of a diaphragm, and strong abdominal muscles. They produce the same effects on the viscera as these muscles would have done, without the inconveniency of giving an additional weight to the body.

Birds have no bladder of urine : But a blueish-coloured canal, or ureter, is sent off from each kidney, and terminates in the rectum. Their urine is discharged along with the faeces. It is a whitish substance, and turns chalky when exposed to the air.

The testicles of the male are situated on each side of the back-bone, and are very large in proportion to the size of the animal. From the testicles proceed two seminal ducts, which at first are straight, but afterwards acquire a convoluted form, as in the epididymus of man. These ducts terminate in the penis, of which the cock has too, one on each side of the common cloaca. They are very small and short ; and, from this circumstance, they long escaped the notice of anatomists.

In the female, the cluster of yolks, being analogous to the human ovaria, are attached to the back-bone by a membrane. This membrane is very thin, and continues down to the uterus. The yolk, after separating from its stalk, passes into a canal called the *infundibulum*, where it receives a gelatinous liquor, which, with what it farther acquires in the uterus,

composes the white of the egg. The uterus is a large bag, situated at the end of the infundibulum, and is full of wrinkles on the inside. Here the egg receives its last covering, or shell, and is pushed out of the vagina at an aperture placed immediately above the anus.

From this description of the structure of granivorous birds, the analogy between them and the herbivorous quadrupeds is conspicuous. In both, the number of their stomachs, the length and capacity of their intestines, and the quality of their food, are very similar. But this analogy is not confined to structure and organs: It extends to manners and dispositions. Like the herbivorous quadrupeds, this order of birds are distinguished by the gentleness and complacency of their tempers. Contented with the seeds of plants, or small insects, the stronger never wage war with the weaker. Their chief attention is occupied in procuring food, in hatching and rearing their young; and their vigilance is kept perpetually active in eluding the snares of men and other rapacious animals. The whole are a timid race, and many of them are so tractable that they may easily be rendered domestic. Man, accordingly, ever attentive to his interest, has not failed to derive advantage from the innocence and stupidity of these animals. Of the gallinaceous and duck kind, which are the most prolific, and consequently the most profitable, he has chiefly selected the hen, the goose, the duck, the turkey, and the peacock. In this selection he has discovered his sagacity; for, instead of pairing, these birds are polygamous, one male being sufficient to fertilize a number of females, which is a great saving in the article of food.

With regard to carnivorous birds, their general conformation is nearly the same with those of the granivorous kind. They have the same number of stomachs; but all of them are smaller and weaker. Their intestines are also much shorter. To enable them to procure food, they are

obliged to fly quickly, and continue long on the wing. Their wings, accordingly, are proportionally longer, and they have more strength in their muscles. For the purpose of seizing and devouring prey, Nature has bestowed on them strong hooked bills, and long sharp claws or pounces. They have also large heads, short necks, strong brawny thighs, and sharp-sighted eyes.

Like rapacious quadrupeds, birds of prey are capable of enduring hunger for a great length of time. This faculty is, perhaps, acquired partly by habit ; because the obtaining of their food is often very precarious. The females are larger, stronger, and more beautiful both in shape and plumage, than the males. For this reason, the male hawks are called *tercels or thirds*, because they are supposed to be one third less than the females. Nature seems to have bestowed this superiority of size and strength upon the female, because she is obliged to procure food both for herself and for her progeny.

The analogy between the structure of rapacious birds and carnivorous quadrupeds is obvious. Both of them are provided with weapons which indicate destruction and rapine. Their manners, are also fierce and unsocial. They never, if the vulture be excepted, herd together in flocks, like the inoffensive granivorous tribes. When not on the wing, they conceal themselves on the tops of sequestered rocks, or in the depths of the forests, where they spend their time in sullen solitude. Those of them which feed upon carion, as the raven, have the sense of smelling so acute, that they scent dead carcasses at amazing distances.

Beside these great divisions of birds into granivorous and rapacious, whose manners and dispositions perfectly coincide with the structure of their bodies, there are other tribes to whom Nature has given peculiar organs. In all these deviations from the common structure, a singularity in the mode

of living, and the oeconomy of the animal, is the invariable result.

Like the amphibious animals, a number of fowls live chiefly in the water, and feed upon fishes and aquatic insects. To enable them to swim and to dive in quest of food, their toes are connected together by broad membranes or webs. By stretching their toes, and striking the water backward with these webs, their bodies are moved forward, and they employ their tail as a rudder to direct their course. Without these additional instruments, fowls could not swim ; and, accordingly, such birds as are not provided with webs never take to the water. But those furnished with webs have such a strong propensity to water, that, when restrained from their favourite element, they discover the greatest uneasiness, and, when their liberty is restored, they fly in a direct course either to the sea, a river, or a lake.

There is another tribe of aquatic birds, some of which feed upon fishes and insects, and others live principally by sucking certain juices from mud. Both these kinds frequent marshy places, or the margins of lakes and rivers. They do not swim, but wade, in quest of food. This singularity in their manners required a correspondent variation in their form and structure. To enable them to wade in waters and in mires, Nature has provided them with long legs, naked of feathers for a considerable space above the knees. Their toes are not, like those of the swimmers, connected by continued membranous webs. Most of them have likewise very long necks and bills, to enable them to search for and apprehend their food. To these tribes belong the crane, the herons, the bittern or miredrum, the stork, the spoon-bill, the woodcock, the snipe, and many other species.

Having given a general idea of the structure and oeconomy of birds, we shall next make a few remarks on the form and manners of fishes.

OF THE STRUCTURE AND ORGANS OF FISHES.

It is one great and benevolent intention of Nature, that no part of the universe should be deprived of inhabitants. The earth, the air, the waters, are full of living beings, who are not only conscious of their existence, but enjoy degrees of happiness proportioned to their natures, and the purposes they are destined to answer in the general scale of animation. The different elements in which they live necessarily required a variety in their form, their food, and their manners. The inhabitants of the earth and air have already been partially described : Those of the waters are next to be considered.

The bodies of most fishes are covered with a strong, thick, skin, in which numberless scales are inserted in an imbricated form, or like tiles on the roofs of houses. Many of them, and particularly those which are shaped like the cod, the trout, and the haddock, have a longitudinal line on each side. In these lines there are a number of small ducts or apertures, which throw out a mucous substance that lubricates their skins, and seems to answer the same purposes as the mucous glands or ducts placed in most of our internal organs.

Fishes are destitute of hands and feet. Their progressive motion, therefore, is performed in a manner different from that of quadrupeds and birds. Their instruments of motion are fins, or machines consisting of a number of elastic beams, connected to one another by firm membranes. Their tails are of the same texture. Their spine is remarkably flexible toward the posterior part of the body, and here the strongest muscles are likewise inserted. They have a power of contracting and dilating their tails at pleasure ; by which means, and by the assistance of the fins, they move forward in the same manner as a boat with oars on its sides and a rudder at its stern. Fishes have no neck : As they seek

their food in a horizontal position, and can move their bodies either upward or downward, a long neck would necessarily have impeded their motion through the water.

The form of fishes is extremely various; and, if their history were sufficiently known, the connection between their structure and their manners would be equally apparent as in the other tribes with which we are better acquainted. Some fishes are long and cylindrical, as the sea-serpent, and all the eel-shaped species. The eel-kind, from their figure, are enabled to trail their bodies along the bottom, and to conceal themselves below the sand or mud. Others are less cylindrical, and proportionally shorter, as the mackrel, the cod, the herring, the salmon, &c. These, from the number and position of their fins, as well as from the shape of their bodies, are destined for quicker motion, and for travelling to great distances in quest of food, or for spawning in shoals or in rivers. Others, as the flounder, the skate, the turbet, torpedo, &c. are broad and compressed. These, like the eel-kind, frequent muddy bottoms. Others are triangular, quadrangular, round, &c. Beside those which approach to regular figures, the variations and compositions are so numerous, that the forms of fishes are much more diversified than those of quadrupeds or birds. To defend themselves against their enemies, many fishes are armed with strong, sharp spines or prickles. For the same purpose, and likewise for wounding or killing their prey, some have a large horn on their front, and others a sword, or rather a saw, which are tremendous weapons. The more timid and defenceless tribes are endowed with the faculty of rapid motion; and some of them have fins so large and flexible, that, when hard pursued, they are enabled to leave their natural element, to dart through the air to considerable distances, and disappoint the designs of their enemies.

Fishes are as much diversified in size as in figure. The ocean produces the largest animals which now inhabit this globe. The enormous masses of the whale and walrus tribes far exceed those of the elephant, rhinoceros, or river-horse, the largest terrestrial animals of which we have any proper knowledge. From the immense bones, however, found in Siberia and many parts of Europe, we are induced to believe, that land animals have formerly existed whose size must have been much larger than that of the present elephant. This animal, whose species is now supposed to be extinguished, is known among naturalists by the denomination of the *mammoth*. Near the river Ohio, some prodigious bones and teeth have lately been discovered, which indicate an animal of incredible magnitude.

With regard to internal structure, fishes like land-animals, are furnished with a back-bone and ribs, which run from the head to the tail. To these, the bones of the head, and the fins, all the muscles and instruments of motion, are attached,

The mouths of most fishes are furnished with teeth ; but in some, as the mullet, sturgeon, &c. the teeth are wanting. In some, the teeth are situated on the jaw-bones, in others, on the tongue and palate. The teeth of fishes are principally designed for laying hold of and detaining their prey, which they generally swallow entire. For this purpose, the teeth are commonly ferrated, or bent inward, like tenter-hooks. By this structure, small fishes are easily forced downwards, and their return is at the same time prevented.

In fishes, the organ of smelling is large ; and they have a power of contracting and dilating, at pleasure, the entry into their nose.

It was formerly doubted whether fishes were endowed with the sense of hearing. But that doubt is now fully re-

moved ; because it has been found, that, like other animals, they have a complete organ of hearing, and that water is a proper medium for the conveyance of sound. Besides, in the in the skate, and some other genera, the learned and ingenious Dr. Monro, Professor of Anatomy in the College of Edinburgh, has lately discovered an aperture which leads directly to the internal parts of the ear.

The gullet of fishes is so short that it is hardly to be distinguished from the stomach, which is of an oblong figure. The guts are very short, making only three convolutions, the last of which terminates in the common vent for the faeces, urine, and semen. From this structure of the stomach and intestines, analogy would lead us to conclude, that fishes live chiefly upon animal food. Experience, accordingly, teaches us, that almost all fishes prey upon the smaller kinds, and even devour their own young. The liver is proportionally large, of a whitish colour, and situated on the left side. The gall-bladder lies at a considerable distance from the liver, and discharges the gall into the gut. In fishes, the organs of generation are two bags situated in the abdomen, and uniting near the anus. In the male, these bags are filled with a thick whitish substance called the *milt*, and in the female with an infinite number of minute eggs called the *roe*. At the season of spawning, the bags, of both male and female are greatly distended ; but, at other times, the male organs can scarcely be distinguished from those of the female.

The swimming bladder is an oblong, white, membranous bag, which contains nothing but a quantity of elastic air. It lies close to the back-bone, and has a pretty strong muscular coat. By contracting this coat, and, of course, condensing the air it contains, some fishes are enabled to render their bodies specifically heavier than water, and to sink to the bottom ; and, when the muscular fibres cease to act, the

air dilates, and makes their bodies specifically lighter. By this curious piece of mechanism, the animals have the power of sinking to the bottom, or of rising to the surface. According to the different degrees of contraction and dilation of this bladder, fishes can, at pleasure, keep themselves higher or lower in the water. Hence flounders, soles, skate, and other fishes which have no swimming bladder, always grovel at or near the bottom. It is likewise a consequence of the relaxation of this bladder, that dead fishes which are furnished with it uniformly rise to the surface. The air-bag, in some fishes, communicates, by a duct, with the gullet, and, in others, with the stomach. At the upper end of the air-bag, there are red-coloured glandular bodies connected with the kidneys. From the kidneys the ureters proceed downward to their insertion in the urinary bladder, which lies in the lower part of the abdomen, and the urethra terminates in the anus.

Fishes have a membranous diaphragm, or midriff, that forms a sack in which the heart is contained. The heart is of a triangular figure. It has only one auricle, one ventricle, and one great artery. This artery, instead of supplying all the parts of the body, as in the frog, is distributed entirely on the gills. All the branches terminate there, and become at last so small that they escape the naked eye. The branchiae, or gills, lie in two large flits on each side of the head, and are analogous to the lungs of land-animals. The figure of the gills is semicircular, and on each side of them are immense numbers of fibrils resembling fringes. The gills are perpetually subjected to an alternate motion from the pressure of the water and the action of the muscles. They are covered with a large flap, which allows an exit to the water necessarily taken in by the animals every time their mouths are opened. The blood is again collected by a vast number of small veins, which, instead of going back a

second time to the heart, immediately unite, and form an aorta descendens, which sends off branches to supply all the parts of the body, except the gills. From the extremities of these branches the blood is collected by veins, and returned to the heart nearly in the same manner as in other animals.

The organs by which the nutritious part of the food of fishes are extracted and conveyed to the general mass of blood, and known by the names of lacteal, absorbent, and lymphatic vessels, are so analogous to those of men and quadrupeds, that it is unnecessary to describe them. For the same reason, no description shall be given of the nerves, which, as in other animals, proceed from the brain and spinal marrow, and are distributed over every part of the body.

Having finished this sketch of the structure and organs of fishes, it is almost needless to remark, that, though they live in a different element, and vary greatly from land animals in figure, Nature, in the formation of their bodies, in the mode of their nutrition, respiration, and sensation, has acted upon the same great and general plan.

We are now to take a view of the structure of insects, a numerous class of animals, most of whom recede farther from the common mode of animal organization than any of the other classes.

OF THE STRUCTURE OF INSECTS.

In the first chapter, a few observations were made concerning the structure and organs of insects, in order to show more clearly the analogies between animals and vegetables. These it is unnecessary to repeat. We shall therefore proceed to a more particular examination of the structure of insects, and to trace the connection between that and their manners.

Insects exhibit such an immense variety in figure, colour, and disposition of parts, that Naturalists have found it neces-

fary to arrange them into different tribes or families. These tribes are distinguished from one another by certain peculiarities in the structure of their bodies.

The most general division of insects is derived from the circumstance of their having or wanting wings, and from the number and substances of which these instruments of motion are composed. They are distinguished from all other animals by many peculiarities of form. None of the other classes have more legs than four. But most insects have six; and many of them have eight, ten, fourteen, sixteen, eighteen, and even a hundred, legs. Beside the number of legs, insects are furnished with antennae or feelers. These feelers, by which insects grope and examine the substances they meet with, are composed of a great number of articulations or joints. Linnaeus, and other Naturalists, maintain, that the uses of these feelers are totally unknown. But the slightest attention to the manner in which some insects employ their feelers will satisfy us of at least one use they derive from these organs. When a wingless insect is placed at the end of a twig, or in any situation where it meets with a vacuity, it moves the feelers backward and forward, elevates, depresses, and bends them from side to side, and will not advance farther, lest it should fall. Place a stick, or any other substance, within reach of the feelers; the animal immediately applies them to this new object, examines whether it is sufficient to support the weight of its body, and instantly proceeds in its journey. Though most insects are provided with eyes, yet the lenses of which they consist are so small and convex, that they can see distinctly but at small distances, and, of course, must be very incompetent judges of the vicinity or remoteness of objects. To remedy this defect, insects are provided with feelers, which are perpetually in motion while the animals walk. By the same instruments, they are enabled to walk with safety in the dark.

No other animals but the insect tribes have more than two eyes. Some of them have four, as the phalangium ; others, as the spider and scorpion, have eight eyes. In a few insects, the eyes are smooth ; in all the others, they are hemispherical, and consist of many thousand distinct lenses. The eyes are absolutely immovable : But this defect is supplied by the vast number of lenses, which, from the diversity of their positions, are capable of viewing objects in every direction. By the smallness and convexity of these lenses, which produce the same effect as the object glass of a microscope, insects are enabled to see bodies that are too minute to be perceived by the human eye.

Another peculiarity deserves our notice. No animal, except a numerous tribe of four-winged insects, have more than two wings.

With regard to sex, quadrupeds, birds, and fishes, are distinguished into males and females. But the bee and the ant furnish examples of neuters, which are absolutely barren : And the earth-worm, and several shell insects, are hermaphrodite, each individual possessing the prolific powers of both male and female.

It is likewise remarkable, that all winged insects undergo three metamorphoses or changes of form : The egg is discharged from the body of the female in the same manner as in other oviparous animals. By a wonderful instinct, these seemingly stupid creatures uniformly deposit their eggs on such animal or vegetable substances as furnish proper food for the worm or caterpillar, that is to be hatched by the heat of the sun. The worm or caterpillar is the first state. The bodies of caterpillars are soft and moist. They have no wings, and are totally deprived of the faculty of generation. After continuing for some time in this reptile state, they are transformed into a chrysalis, which is drier and harder than the caterpillar. The chrysalis of some

insects are naked, and those of others are covered with a silken web, spun by the animals before their change is completed. In this state, many of them lie motionless, and seemingly inanimate, during the whole winter. When the spring or summer heats return, they burst from their last prison, and, from vile reptiles, are transformed into beautiful flies. In this perfect state they are exceedingly active, fly about in quest of their mates, and, after propagating their species, the females deposit their eggs, and the same circle of animation and change perpetually goes round. Hence the structure and figure of the same individual animals are three-fold, which renders the knowledge of insects extremely complicated, as we must be acquainted with them in the several forms they successively assume.

There is another peculiarity in the structure of insects. They are deprived of bones. But that defect is supplied, in some, by a membranous or muscular skin, and, in others, by a crustaceous or horny covering. In this circumstance, insects resemble the shell-animals, whose bones constitute the external parts of their bodies.

In general, the bodies of insects are composed of a head, trunk, and abdomen. The head is commonly attached to the trunk by a joint or articulation. Beside eyes, feelers, and mouth, the heads of some insects are furnished with *palpi* fixed to the mouth ; and they are either four or six in number. Each of them consists of two, three, or four joints, and are often mistaken for the antennae or feelers. These instruments seem to serve the animals instead of hands ; for they employ the palpi to bring the food to their mouths, and to keep it steady while eating. It is asserted by Linnaeus, and other Naturalists, that the heads of insects are destitute of brains, nostrils and ears. The minuteness of the animals under consideration may have hitherto prevented us from distinguishing these organs. If they want a brain, it

is certain that their sense of seeing is acute ; and we know that they are amply supplied with nerves, which produce the same effects as the brain in larger animals. If they are deprived of nostrils, the slightest attention must convince us, that some of them possess the sense of smelling in a very high degree. Upon any other supposition, how should the different species of flies, the moment they escape from the chrysalis state, distinguish, and directly approach, the different animal and vegetable substances Nature has destined for their respective nourishment ? A piece of meat is no sooner exposed to the air than it is covered with flesh flies, upon which they both feed and deposit their eggs. Without this sense, how should wasps, and other flies, be allured from considerable distances into bottles encrusted with honey or molasses ? These, and similar actions, cannot be effects of sight ; for the distance, the minuteness, and frequently the position of the food, render it impossible for the eye to discover those substances to which they instantly resort.

With regard to hearing, it is more difficult to determine whether insects be endowed with this sense. We can judge of it, not by the knife of the Anatomist, but by the affections and motions of the animals themselves. Several trials I have made on house-flies incline me to think that these animals possess a sense of a nature similar, at least, to that of hearing. At the distance of three or four feet, a smart stroke, even upon a stone wall, alarms and puts them to flight. But this may partly be attributed to the vibration in the wall, or the concussion of the air, produced by the stroke. To obviate this difficulty, at the same distance of between three and four feet, I struck the air repeatedly with a bookbinder's folder, without giving the smallest alarm to the flies. But, when I struck the folder against the boards of a book, which I held in my hand, and made a smart noise, the animals were instantly alarmed, and flew off at the second stroke.

The same effect is produced in a room just light enough to render the animals visible. These trials, which I have often repeated, seem to indicate that flies, if they are really deprived of ears, are endowed with an analogous sense, though we are ignorant of its situation.

Naturalists have limited the senses of insects to those of seeing and feeling. But the above remarks render it more than probable that flies possess likewise the senses of smelling and of hearing : Neither should the sense of taste be denied them ; for, though they may be assisted by smelling to discover and select their food, we cannot suppose that Nature has denied them the pleasure which other animals so universally derive from eating. Besides, an agreeable sensation, similar to that of taste, must accompany an action which removes the pain arising from hunger.

The mouth of insects is generally placed in the under part of the head ; but, in some, it is situated in the breast. The jaws, instead of being horizontal, are often transverse, and furnished with teeth. The greater number of winged insects are provided with a proboscis or trunk, an instrument by which they extract the juices from animal or vegetable substances. The proboscis of insects is a machine of a very complicated nature. In butterflies, the proboscis is situated precisely between the two eyes. Though some of them exceed three inches in length, they occupy but a small space. When a butterfly is not in quest of food, the proboscis is rolled up in a spiral form, similar to that of a watch-spring, each successive ring covering the one which precedes. The substance of the proboscis has some resemblance to that of horn. It tapers from the base to the extremity. It is composed of two similar and equal parts, each of which is concave, and, when joined, form three distinct tubes. Reaumur has rendered it probable, that these tubes enable the animals to extract the juices of plants, to conduct air into their

bodies, and to convey the sensation of smelling. Hence the proboscis of insects is an instrument which serves them for a mouth, a nose, and a wind-pipe.

The upper part of the trunk or body of insects is called the thorax, and the under part the abdomen or belly. The abdomen contains the stomach and other viscera. It consists of several rings or segments, and is perforated with spiracula, or tubes, which supply the want of lungs. The abdomen is terminated by the tail, which, in some insects, is armed with a sting, a forceps, a bristle, or a kind of claw with a moveable thumb.

The legs are composed of three parts, connected to each other by joints, and represent the thighs, shanks, ankles, and feet of larger animals.

The wings of insects are so diversified in number, consistence, and colour, that Linnaeus has made them the foundation of the several orders or divisions into which he divides this numerous class of animals. Some insects are furnished with four, and others with two wings, and some of them are entirely destitute of these instruments of motion.

The four-winged insects are arranged into five orders. The first order Linnaeus distinguishes by the name of *coleoptera*, or those insects whose upper pair of wings consist of a hard, crustaceous, or horny substance. These cover and defend the under pair, which are of a more soft and flexible texture. This order comprehends the whole of what is properly called *scarabaei*, or the beetle tribe. Like other winged insects, all the beetles live for some time in the form of caterpillars, or grubs.

As a farther confirmation of the connection of manners with form and structure, it is here worthy of remark, that the same animals, when in the state of caterpillars, live in a different manner, and feed on substances of a very different kind from those they consume after their transformation into

flies. The caterpillars of the garden-beetle, cock-chaser, &c. lead a solitary life under ground, and consume the roots of plants. Those of others feed upon putrid carcasses, every kind of flesh, dried skins, rotten wood, the dung of men and quadrupeds, and the small insects called *pucerons*, or *vinefretters*. The devourers of the puceron contribute to cure such plants as happen to be infected with the *phthiriasis*, or lousy disease. But, after their transformation into flies, many of the same animals, which formerly fed upon dung and putrid carcasses, are nourished by the purest nectareous juices extracted from fruits and flowers. The creatures themselves, with regard to what may be termed *individual animation*, have suffered no alteration. But the fabrick of their bodies, their instruments of motion, and the organs by which they take their food, are materially changed. This change of structure, though the animals retain their identity, produces the greatest diversity in their manners, their oeconomy, and the powers of their bodies. In the caterpillar state, these animals are extremely voracious, and, in many instances, acquire a greater magnitude than they possess after transformation; but they are incapable of multiplying their species, and of receiving nourishment from the same kinds of food. Besides, many caterpillars, previous to their transformation, live even in a different element. The ephemeron fly, when in the caterpillar state, lives no less than three years in the water, and extracts its nourishment from earth and clay. After transformation, this animal seldom exists longer than one day, during which the species is propagated, and myriads of eggs are deposited on the surface of the water. These eggs produce worms or caterpillars, and the same process goes perpetually round.

Linnaeus's second order of insects, or *hemiptera*, have likewise four wings. But the upper pair, instead of being hard and horny, rather resemble fine vellum. They cover the

body horizontally, and do not meet in a direct line, forming a ridge or future, as in the beetle tribe. The whole of this order are furnished with a proboscis or trunk for extracting their food.

This order comprehends several genera or kinds, some of which we shall mention in a cursory manner.—The *blatta*, or *cockroach*, is an animal which avoids the light, and is particularly fond of meal, bread, putrid bodies, and the roots of plants. It frequents bakers shops and cellars, and flies the approach of danger with great swiftness.—The head of the *mantis*, or *camel-cricket*, appears, from its continual nodding motion, to be slightly attached to the thorax. This insect is regarded by the Africans as a sacred animal ; because it frequently assumes a praying or supplicating posture, by resting on its hind feet, and elevating and folding the first pair. The *gryllus* comprehends a number of species, some of which are called *grasshoppers*, others *locusts*, and others *crickets*. The *larvae*, or caterpillars of the *grylli*, have a great resemblance to the perfect insects, and, in general, live under ground. Many of these insects feed upon the leaves of plants. Others, which live in houses, prefer, bread, and every kind of farinaceous substance.—The *fulgora*, or *fire-fly* : The foreheads of several of this genus, especially of those that inhabit China, and other hot climates, emit a very lively shining light during the night, which often alarms those who are unacquainted with the cause of the appearance.—The *cicada*, *frog-hopper*, or *flea-locust* : The *larvae*, or caterpillars, of some of this genus, discharge a kind of froth or saliva from the anus and pores of the body, under which they conceal themselves from the rapacity of birds and other enemies.—The *papa* or *water scorpion*, frequents stagnant waters. It lives chiefly on aquatic insects, and is exceedingly voracious.—The *cimex* or *bug* : Many species of this genus feed upon the juices of plants, and others upon the blood of animals. Some of them

are found in waters, and others frequent houses, among which, though it wants wings, is the bed-bug, a pestiferous insect, which is too well known, and too generally diffused. The bugs differ from other insects by their softness; and most of them emit a very foetid smell. The *aphis*, *puceron*, or *vine-fretter*: These insects are very common, and are generally termed the *lice* of the plants which they infest: The puceron, as remarked in the first chapter, is viviparous in summer, and oviparous in autumn. Numbers of them are devoured by the ants, on account, as is supposed, of a sweet liquor with which their bodies are perpetually moistened. *Chermes*: The *larvae* or caterpillars of this insect have six feet, and are generally covered with a hairy or woolly substance. The winged insects leap or spring with great agility, and infest a number of different trees and plants: The females, by means of a tube at the termination of their bodies, insert their eggs under the surface of the leaves, and the worms, when hatched give rise to those tubercles, or galls, with which the leaves of the ash, the fir, and other trees, are sometimes almost entirely covered.

The third order or tribe of four-winged insects consists of three genera only. But the species comprehended under them are exceedingly numerous. All butterflies and moths belong to this order. Their wings are covered with a farinaceous powder, or rather with a kind of scales or feathers, disposed in regular rows, nearly in the same manner as tiles are laid upon the roofs of houses. The elegance, the beauty the variety of colours exhibited in their wings, are produced by the disposition and different tinctures of these minute feathers. The insects of this order, on account of their beauty and easy preservation, have always been the favourites of collectors, and particularly of those of the female sex. When the feathers are rubbed off, the wings appear to be nothing

more than a naked, and often a transparent membrane. The feelers of the *papilio*, or *butterfly*, are thickest at their extremity, and often terminate in a kind of capitulum, or head. Their wings, when sitting, or at rest, are erect, their extremities join each other above the body, and the animals fly about, in quest of food and of their mates, during the day. The *moths* are divided into two genera, the one called *sphinx*, or *hawk moth*, and the other *phalaena*, or *moth*. The feelers of the *sphinx* are thicker in the middle than at the extremities, and their form, in some measure, resembles that of a prifin. The wings are, in general, deflected, their outer margins declining towards the fides. They fly about early in the morning, and after sun-set; and, by means of their proboscis, like the butterflies, they suck the juices of plants. The *phalaena*, or *moth*: The feelers of this genus are feta-ceous, and taper from the base to the point. When at rest, their wings are commonly deflected; and they fly during the night. Previous to their transformation, the caterpillars of the whole of this genus spin webs for covering and protecting the animals while in the chrysalis state. From a species of this tribe mankind have derived one of the greatest articles of luxury and of commerce which now exists in the world. That seemingly contemptible, that disgusting reptile known by the appellation of the *silk-worm*, in its passage from the caterpillar to the chrysalis state, produces those splendid materials which adorn the thrones of Princes, and add dignity and lustre to female beauty*.

The wings of the *fourth* order, distinguished by the name of *neuroptera*, are membranaceous, naked, and so interspersed with delicate veins, that they have the appearance of beautiful net-work. Their tail has no sting; but that of the male is frequently furnished with a kind of forceps or pincers. To this order belongs the *libella*, or *dragon-fly*, an insect of very splendid and variegated colours. It is a large and well

* See Chap. XI, concerning the Transformation of Animals.

known fly, and frequents rivers, lakes, pools, and stagnating waters, in which the females deposit their eggs. Their mode of generating is singular. Different species of them appear from the beginning of summer to the middle of autumn. They generally fly in pairs and in a straight line, the male pursuing the female. The organs of the male are situated in his breast: When he overtakes her, with the forceps in his tail he lays hold of her by the neck, while she, by an instinctive impulse, makes the lower end of her body approach the male organs. In this united situation they form a kind of ring, have the appearance of a double animal, and fly along till the purpose is accomplished. Under the same order is comprehended the *phryganea*, or *spring-fly*: The larvae or caterpillars of this genus live in the water, and are covered with a silken tube. They have a very singular aspect; for, by means of a gluten, they attach to the tubes in which they are inclosed small pieces of wood, sand, gravel, leaves of plants, and not unfrequently live testaceous animals, all of which they drag along with them. They are very commonly found in salads of the water-cress; and, as they are often entirely covered with green leaves, they have the appearance of animated plants. They are in great request among fishermen, by whom they are distinguished by the name of *stone*, or *cod-bait*. The fly, or perfect insect, frequents running waters, in which the females deposit their eggs.

The fifth order is termed *hymenoptera*. In general, the insects belonging to this order have four membranaceous and naked wings. In some of the genera, however, the neuters, and, in others, the males, or even the females, have no wings. Their tails except in the male sex, are armed with a sting.—The female of the *cynips*, an insect belonging to this order, inserts her eggs into the leaves of the oak, and the caterpillars produced from them give rise to the galls employed in the composition of ink. This order likewise includes the

wasp, the bee, and the ant. Many of the wasp kind, like the bees, live in society, make combs in which the females deposit their eggs, and feed their caterpillars with an inferior species of honey. Others of them construct a separate nest for each individual egg. The bee is an insect too well known to require a particular description. The males have no sting; but the females, and the drones, or neuters, have a very sharp pointed sting concealed in their abdomen. The female of the honey bee is much larger than the male, or the neuter. Her feelers contain fifteen articulations. Her abdomen is composed of seven segments, and is much longer than her wings. The feelers of the male contain only eleven articulations. The neuters are much smaller than the males or females, and their feelers consist of fifteen articulations. The sting, with which the male and female *ants* are armed, is concealed within the abdomen. The males and females of the ant are furnished with wings, but the neuters are deprived of these instruments of motion. The ants live in societies which are composed of males, females, and neuters. The males are much smaller than the females and neuters. Soon after the males and females propagate the species, they all die. Some of the neuters, however, survive the winter; but they remain in their habitation without movement, or discovering any signs of life. From these circumstances in the history of ants, it is apparent, that the industry and sagacity so long and so universally ascribed to these little animals could be of no use either to themselves or their progeny. The female, after depositing her eggs, takes no farther care of her offspring. But, what is singular, the important office of feeding the *larvae*, or caterpillars, after the eggs are hatched, is left entirely to the neuters. This affectionate and assiduous attention of the neuters to a progeny neither begot nor brought forth by them, is so astonishing, so con-

trary to the general oeconomy of Nature, that no reasoning or theory can account for a fact so uncommon, till farther discoveries shall be made in the history of these surprising animals. What is still more singular, after the caterpillars are transformed into the chrysalis state, the neuters are incessantly and anxiously employed in preserving the chrysaes from humidity when the weather is wet, and in exposing them to the warmth of the sun when it is fair. These chrysaes are larger than the animals themselves, and yet they carry them off with ease and rapidity.

The *sixth* order of insects is termed *diptera*, or two-winged insects. The different species of this order, beside wings, are furnished with what is called a *halter* or a *poiser*, which is situated under each wing, and is terminated by a *capitulum*, or knob. This order comprehends ten genera and a multitude of species. The caterpillars of the *oestrus*, or *gadfly*, lie concealed in the skins of cattle, where they are nourished during the whole winter. The perfect insects are frequent wherever horses, cows, or sheep, are grazing. Some of them deposit their eggs in the skins of cows or oxen; others deposit them in the intestines of horses, to which they get access by the anus; and others in the nostrils of sheep. In these habitations, the caterpillars reside till they are full grown, when they throw themselves down to the earth, and generally pass the chrysalis state under the first stone they meet with. The *musca*, or common *fly*: The mouth of this insect consists of a soft, fleshy proboscis, with two lateral lips. The caterpillars of some of this genus devour the pucerons; others consume all kinds of putrid flesh; others are found in cheese; others in the excrements of different animals; and many of them live in the water, and prefer that which is most corrupted and muddy. The mouth of the *culex*, or *gnat* consists of a flexible sheath, inclosing four bristles, or pointed stings. The feelers of the female gnat are plain like

a thread ; but those of the male are beautifully feathered. The worms or caterpillars of this genus are commonly found in stagnant waters. The gnats generally frequent woods and marshy places. The females, in particular, are very troublesome, and sting severely. The feet of the *hippobosca* or *horse-fly*, are armed with a number of nails or crotchets. In some species, the wings cross each other ; in others, they are open. The horse-flies frequent woods and marshy grounds, and are extremely incommodious to birds and quadrupeds, whose blood is the only food of these insects.

The seventh order of insects Linnaeus denominates *aptera*, because neither males nor females are furnished with wings. This order comprehends thirteen genera, and a great number of species, many of which are very offensive and noxious to the human species. The *pediculus*, or *louse*, has six legs, two prominent eyes, and its mouth contains a sting or sucker, by which it extracts blood and other juices from the bodies of animals. Though almost every different animal is infested with a peculiar species of lice, specific characters of very few of them have hitherto been ascertained. Lice are of various forms. Some of them are oval, others oblong, and others long and slender. They are oviparous animals, and their eggs are large in proportion to the size of their bodies. Before they arrive at maturity, they change their skin several times. They are supposed to be hermaphrodites. This circumstance, if true, may partly account for their prodigious multiplication. Swammerdam, who dissected a great number, assures us, that he never found one without an ovary, nor ever discovered the organs peculiar to the male sex. If this structure be universal, the louse is an hermaphrodite of a very peculiar kind ; because it must be capable of foecundating itself. Several species of worms are hermaphrodites ; but, instead of foecundating themselves, they are obliged to impregnate each other. The *pulex*, or *flea*, has likewise six legs,

the articulations of which are so exceedingly elastic, that the animal is enabled by their means, to spring to surprising distances. It has two fine eyes, and its body is covered with crustaceous scales. The flea is the only insect belonging to this order which undergoes a transformation similar to that of the former orders : All the other wingless insects are produced in a perfect state either by the mother, or from eggs. The caterpillars of the flea have forked tails, and are very small and lively. They may be nourished in boxes, and fed with flies, which they greedily devour. Before changing into the chrysalis state, they live fourteen or fifteen days in the form of caterpillars. *Aranea*, or spider : This genus comprehends a great many species. The spider has eight feet, and an equal number of immoveable eyes. The chief prey of the spider is flies, animals whose motions are extremely quick and desultory. To enable the spider to observe their movements in every direction, she is furnished with eight eyes, the position of which merits attention : Two of them are placed on the top of the head, other two on the front, and two on each side. The mouth is armed with two crotchets, by which it seizes and kills its prey. Round the anus there are several muscular instruments, shaped like nipples or teats. Each of these contain about a thousand tubes or outlets for threads so extremely minute, that many hundreds of them must be united before they form one of those visible ropes of which the spider's web is composed. The figure of the web varies according to the species, or the situation the animal chooses for its abode. After the web is completed, some species reside in the center, and others occupy the extremity of their habitations, where they lie in ambush, with astonishing patience, till an ill-fated fly is accidentally entangled. The spider, from the vibration of the threads, perceives his prey, rushes forth from his cell, instantly seizes it with his fangs, devours its vitals, and after-

wards rejects the exhausted carcase. Spiders prey upon all weaker insects, and even upon their own species. The scorpion; this venomous insect is a native of warmer climates than those of the north of Europe. It has eight feet, and two claws, the last of which are situated on the fore part of the head. Like the spider, the scorpion has eight eyes, three of which are placed on each side of the breast, and the other two on the back. The tail is long, jointed, and terminates in a sharp crooked sting. The venom of the scorpion is more destructive than that of any other insect; and is sometimes fatal in Africa and other hot regions.

The *last* division of insects is termed *vermes* or *worms*, by Linnaeus. This class comprehends not only all the insects commonly called *worms*, but all the testaceous animals, and the zoophites, or plant-animals. The structure of several genera belonging to this class is extremely singular. After giving a few examples, we shall hasten to the conclusion of the present subject.

The body of the *gordius*, or *hair-worm*, is long, shaped like a thread or hair, smooth, and round. A species of the hair-worm is very common in our fresh waters, and is perfectly harmless. In Scotland, it is a vulgar and foolish notion, that the hair of a horse's tail, when thrown into the water, is converted into this worm. Though inoffensive in this country, the hair-worm of Africa, and of both the Indies, is extremely noxious. It is of a pale yellowish colour, and is frequently met with among the grafts, especially when covered with dew. It often insinuates itself into the naked feet or limbs of children and unwary persons, where it produces an inflammation, which is sometimes fatal. It may be extracted by tying a thread round its head, and then pulling it gently out of its abode. But this operation requires great caution; for, if the animal is broken, the part which remains does not die, but, in a short time, regains what it had lost,

and becomes equally entire and troublesome as if it had received no injury. The *lumbricus* or *earth-worm* : The body of this worm is cylindrical, consists of many rings, and the middle is encompassed with an elevated belt. It is likewise furnished with sharp prickles, which the animal can erect or depress at pleasure. Through certain perforations in the skin, it occasionally emits a slimy fluid, which lubricates its body, and facilitates its passage into the soil. The intestines of this worm are always filled with a fine earth, which seems to constitute its only nourishment. Earth-worms, like snails, are hermaphrodite. The parts of generation are placed near the neck, and they mutually impregnate each other. This operation is performed on the surface of the ground ; and, while thus employed, they will allow themselves to be crushed to pieces rather than part. The females deposit their eggs in the earth, where they are hatched. These worms, like the polypus, when cut through the middle, reproduce, and each portion becomes a distinct individual. According to the different periods of their growth, their colour varies ; but, in general, it is a dusky red.

The *sepiā*, or *cuttle-fish*, though comparatively a large animal, some of them being two feet long, is ranked by Linnaeus under the class of *worms*. The structure of the cuttle fish is remarkable. Its body is cylindrical, and, in some of the species, is entirely covered with a fleshy sheath ; in others, the sheath reaches only to the middle of the body. The *sepiā* has eight tentacula, or arms, beside two feelers, as they are called, which are much longer than the arms. Both the feelers and arms are furnished with strong cups, or suckers, shaped like the cup of an acorn, by means of which the animal seizes its prey, and firmly attaches itself to rocks, or to the bottom of the sea. It has two large and prominent eyes. What is still more singular, it is furnished with a hard, strong, horney beak, precisely similar, both in texture and

substance, to the bill of a parrot. With this bill, the cuttle-fish is enabled to break the shells of limpets, and other shell-animals, upon which it chiefly feeds. In the belly, there is an aperture through which the animal, when pursued by its enemies, emits a fluid as black as ink, tinges the water, and often escapes by this ingenious stratagem. The Ancient Romans frequently used this black fluid as ink in writing. The males and females copulate by a mutual embrace. The female deposits her eggs upon sea-plants in parcels resembling bunches of grapes. At the instant they drop from the mother, the eggs are white ; but the male immediately coats them over with a black liquor. The male perpetually accompanies the female. When the female is attacked, he braves every danger, and often rescues her at the hazard of his own life. The bone of the cuttle-fish is very light, and, when pulverized, it is employed by different artists in making moulds.

The *medusa* is an animal which has the appearance of a lifeless mass of jelly floating on the surface of the ocean. Its body is roundish, flattened underneath, and the mouth is situated in the centre of the under part. There are many species of this seemingly most imperfect, defenceless, and abject part of animated nature. They are, however, furnished with tentacula, by which they seize insects and the small fry of fishes, convey them to their mouths, and devour them. Although the sport of the waves, and the prey of every fish that approaches them, they are gregarious animals, and, particularly in warm climates, sometimes collect in such numbers as to have the appearance of whitish rocks under the surface of the ocean.

WE have thus given a short sketch of the structure of animals, from man down to the insect tribes, and shall now conclude with a few remarks.

In all the variety of animated beings whose general structure has been exhibited, the intelligent reader will easily perceive, that the bodily forms of the different kinds are exactly adapted to the rank they hold in the creation, and that their oeconomy and manners are strictly and invariably connected with their structure and organs. If a new animal appears, and if its figure be uncommon, it may with safety be pronounced, that its manners are equally uncommon. Change the external or internal form of an animal; diminish the number of stomachs in the ruminating tribes; or give to the horse a parrot's bill; and the species will be annihilated.

The comparative power, or strength, of animals depends not on structure alone. Mental faculties, and docility, or the capacity of receiving instruction, seem to be the greatest sources of animal power. Hence man's unlimited empire over all other creatures. The inventions of language, of arms, of writing, printing, and engraving, have been the chief means of extending his influence, and of his acquiring the dominion of the earth. By these arts, men transmit the improvements, the inventions, and the acquisitions, of one age to another. By these arts, the dispositions of men are softened, their manners become more and more civilized, humanity is gradually extended and refined, and the grosser animosities yield to external politeness and decorum at least, if the feelings themselves be not blunted. How far this progress of science, and the peaceful arts of life, by the accumulation of ages, may proceed, it is impossible to determine. But the time, it is to be hoped, is not very remote, when the fiercer contentions of nations will cease, when selfishness and venality, which at present seem to be inseparable from commercial states, will give way to generosity of temper, and uprightness of conduct.

CHAPTER III.

Of the Respiration of Animals—Air necessary to the existence of all animated beings—The various modifications of the organs employed by Nature for the transmission of Air into animal bodies.

IT is foreign to the design of this chapter to mention the different kinds of air; to unfold its composition; or to recapitulate the innumerable benefits derived from it in the animal and vegetable kingdoms, in the arts of life, and in the texture and cohesion of inanimate bodies. For our purpose, it is sufficient to observe, that by *air* is meant that common elastic fluid which pervades this globe, and which by its weight, its pressure in all directions, and its compressibility, insinuates itself into every vacuity, and is necessary to the existence of every animal and vegetable being.

In man, and the larger land animals, air is taken into the body by the lungs. When an animal inspires, the external air passes through the apertures of the mouth and nose into the trachea or wind-pipe, and thence directly into the lungs. This air, by insinuating itself into the numerous cells of the lungs, necessarily inflates them, and, when retained for a second or two, produces an uneasy sensation. To remove this disagreeable feeling, the animal instinctively, by the exertion of particular muscles destined by Nature for that purpose, forces out the air, and thus removes the offending cause. The lungs, after the air is thrown out, instead of being inflated, collapse; and, if a fresh supply is not soon taken in, a similar uneasy sensation is felt, which obliges the animal again to inspire. This alternate reception and rejection of air goes on during the life of the animal, and is dif-

tinguished by the general name of *respiration*. But, when treating more accurately of the subject, the act of taking air into the lungs is called *inspiration*, and the act of throwing it out is termed *expiration*.

That the respiration of air is indispensable to the existence of land animals, has been proved by innumerable experiments made with the air-pump. Mice, rats, rabbits, cats, dogs, &c. when placed in an exhausted receiver, instantly become restless, and discover symptoms of pain. Their bodies swell, and their life is soon extinguished. Indeed, our own feelings are sufficient to ascertain this fact. No person can remain long either in a state of inspiration or expiration without being suffocated.

But the alternate motions of inspiration and expiration, joined to the circulation of the blood through the lungs, may be considered as the more mechanical effects of respiration. Though these operations are absolutely necessary to the existence of animals, yet the air itself has been supposed to impart some vital principle to the blood, without which life could not be continued.

The ingenious Doctor Crawford, in his treatise on Animal Heat, has rendered it probable, that the respiration of air is the cause of that vital warmth without which no animal can exist. After mentioning a well known fact, that all bodies, whether animate or inanimate, contain a certain quantity of fire as a principle in their composition, the Doctor remarks, that this quantity, in different bodies, varies according to their nature or texture; that this fire, when in a latent or quiescent state, is termed *absolute heat*; that, when substances of different textures have a given quantity of heat thrown into them, their temperature will be discovered to be different by the thermometer; for the same quantity of heat which raises one body to a certain degree, will raise another to a

greater or a less ; and this different disposition of bodies is called their capacity of containing absolute heat.

Doctor Crawford next endeavours to prove by experiments, that, when phlogiston is added to any body, its capacity of containing absolute heat is diminished ; and that, when phlogiston is abstracted from the same body, its capacity of receiving absolute heat is augmented. Hence he infers, that heat and phlogiston seem to constitute two opposite principles in nature. By the action of heat upon bodies, the force of their attraction to phlogiston is diminished ; and, by the action of phlogiston, a part of the absolute heat, which exists in every substance as an element, is expelled. ‘Hence,’ says the Doctor, ‘animal heat seems to depend upon a process similar to a chemical elective attraction. ‘The air is received into the lungs, containing a great quantity of absolute heat. The blood is returned from the extremities, highly impregnated with phlogiston. The attraction of the air to the phlogiston is greater than that of the blood. This principle will therefore leave the blood to combine with the air. By the addition of the phlogiston, ‘the air is obliged to deposit a part of its absolute heat ; and, as the capacity of the blood is, at the same moment, increased by the separation of the phlogiston, it will instantly unite with that portion of heat which had been detached from the air.

‘We learn from Doctor Priestley’s experiments with respect to respiration, that arterial blood has a strong attraction to phlogiston : It will, consequently, during the circulation, imbibe this principle from those parts which retain it with the least force, or from the putrescent parts of the system : And hence the venous blood, when it returns to the lungs, is found to be highly impregnated with phlogiston. By this impregnation, its capacity for containing heat is diminished. In proportion, therefore, as the blood,

' which had been dephlogisticated by the process of respiration, becomes again combined with phlogiston, in the course of the circulation, it will gradually give out that heat which it had received in the lungs, and diffuse it over the whole system.*'

The Doctor afterwards proceeds to assign a reason why the heat of animals is always equal. ' As animals,' says he, ' are continually absorbing heat from the air, if there were not a quantity of heat carried off, equal to that which is absorbed, there would be an accumulation of it in the animal body. The evaporation from the surface, and the cooling power of the air, are the great causes which prevent this accumulation. And these are alternately increased and diminished, in such a manner as to produce an equal effect. When the cooling power of the air is diminished by the summer heats, the evaporation from the surface is increased ; and when, on the contrary, the cooling power of the air is increased by the winter colds, the evaporation from the surface is proportionally diminished †.'

This theory, though not supported by mathematical evidence, is not only ingenious, but seems to make a nearer approach to truth than any that has hitherto been invented †.

Respiration, beside being the probable cause of the equable continuation of heat in animals, produces many other salutary and useful effects in the oeconomy of animated bodies. There is a most intimate connection between the act of respiring and the circulation of the blood. When respiration is, for a short time, interrupted by the fumes of burning sul-

* Crawford on Animal Heat, pag. 73. † Ibid. pag. 84.

‡ If the reader is desirous of seeing some pertinent remarks on Doctor Crawford's Theory of Animal Heat, he may consult Doctor Gardiner's Observations on the Animal Oeconomy, and on the Causes and Cure of Diseases, an ingenious and useful performance, lately published, and which merits much more attention from Philosophers and Physicians than it has hitherto received.

phur, by mephitic air, or by remaining some minutes under water, the action of the heart ceases. But, in many cases of this kind, the motion of the heart may, and frequently has been renewed, by blowing air into the lungs, and by the application of stimulating substances to different organs of the body. In persons seemingly dead from a temporary suspension of respiration, if the lungs can be excited to act, the motion of the heart instantly commences, the circulation of the blood is restored, and life is recovered. This intimate connection between respiration and the action of the heart, is one of those astonishing facts in the animal oeconomy, the causes of which will perhaps forever elude the keenest researches of the human intellect. All we know is, that certain functions are indispensable to the existence of animals, and that, if any of them are suspended for a few seconds, life is extinguished ; namely, the action of the brain and nerves, the circulation of the blood, respiration, and a probable result of respiration, animal heat. These functions, from their importance in the system, have received the appellation of *vital functions*. There are other functions of the body, called *natural*, which are no less necessary to life, as the digestion and concoction of aliment, the various secretions and excretions. But they are distinguished from the vital functions, because some of them may be suspended for a considerable time without materially injuring the body.

Respiration commences instantly after birth, and is instinctively continued during life. In the foetus state, as formerly mentioned*, respiration is unnecessary, because the circulation of the general mass of blood is carried on through a different channel. In the act of inspiration, we are conscious of making a certain effort ; but in the act of expiration we scarcely perceive any exertion whatever.

* See above, page 66.

Beside the circulation of the blood, and the continuation of the vital warmth, respiration gives rise to many other important functions in the animal oeconomy. All animals who respire, beside a watery vapor, exhale great quantities of mephitic or corrupted effluvia, which, if retained in the lungs, or breathed by other animals, would soon prove fatal. The muscles of respiration, of which we have the command, are employed in many other operations of the body, beside the mere act of breathing air. All animals furnished with lungs express their wants, their affections and aversions, their pleasures and pains, either by words, or by sounds, peculiar to each species. These different sounds are produced by straitening or widening the glottis and wind-pipe, or, in general, the passage through which the air passes in respiration. The inferior animals are by this means enabled to express themselves, though not by articulate sounds, in such a manner as to be perfectly intelligible to every individual of a species. On man alone, Nature has bestowed the faculty of speaking, or of expressing his various feelings and ideas, by a regular, extensive, and established combination of articulate sounds. To have extended this faculty to the brute creation, would not, it is probable, have been of any use to them ; for, though some animals can be taught to articulate, yet, from a defect in their intellect, none of them seem to have any idea of the proper meaning of the words they utter. Speech is performed by a very various and complicated machinery. In speaking, the tongue, the lips, the jaws, the whole palate, the nose, the throat, together with the muscles, bones, &c. of which these organs are composed, are all employed. This combination of organs we are taught to use when so young that we are hardly conscious of the laborious task, and far less of the manner by which we pronounce different letters and words. The mode of pronouncing letters and words, however, may be learned by attentive-

ly observing the different organs employed by the speaker. By this means we are enabled to correct various defects of speech, and even to teach the dumb to speak ; for dumbness is seldom the effect of imperfection in the organs of speech, but generally arises from a want of hearing ; and it is impossible for deaf men to imitate sounds which they never heard, except they be taught to use their organs by vision and by touching.

When about to laugh, we make a very full inspiration, which is succeeded by frequent, interrupted, and sonorous expirations. When the titillation is great, whether it arises from the mind or body, these convulsive expirations sometimes interrupt the breathing to such a degree as to endanger suffocation. Moderate laughing, on the contrary, promotes health : By agitating the whole body, it quickens the circulation of the blood, gives an inexpressible cheerfulness to the countenance, and banishes every kind of anxiety from the mind.

In weeping, we employ nearly the same organs as in laughing. It commences with a deep inspiration, which is succeeded by short, broken, sonorous, and disagreeable expirations. The countenance has a dismal aspect, and tears are poured out. Weeping originates from grief, or other painful sensations either of body or mind : When full vent is given to tears, grief is greatly alleviated. Both laughing and weeping have been reckoned peculiar to man. But this notion seems not to be well founded. Though the other animals express not their pleasures or pains in the same manner as we do, yet all of them exhibit their pleasant or painful feelings by symptoms or cries, which are perfectly understood by the individuals of each species, and, in many instances, by man. A dog, when hurt, complains in the bitterest terms ; and, when he is afraid, or perhaps melancholy, he expresses the situation of his mind by the most deplora-

ble howlings. A bird, when sick, ceases to sing, droops the wing, abstains from food, assumes a lurid aspect, utters melancholy, weak cries, and exhibits every mark of depressed spirits. By this means, animals intimate the assistance they require, or soften those who maltreat them. Their plaintive cries are sometimes so affecting as to disarm their enemies, or procure the aid of their equals. On the other hand, when animals are pleased or caressed, they discover, by their countenance, by their voice, by their movements, unequivocal symptoms of cheerfulness and alacrity of mind. Thus the expressions of pleasure and pain by brute animals, though not uttered in the precise manner with those of the human species, are perfectly analogous, and answer the same intentions of Nature.

By respiration, and the instruments employed in the performance of it, the larger animals are not only brought forth, but are enabled to extract milk from the breasts of the mother. By respiration, odors are conveyed to the nose; coughing, sneezing, yawning, sighing, singing, vomiting, and many other functions in the animal oeconomy, are at least partly accomplished.

After this general view of the respiration of man and of quadrupeds, we proceed, according to the method laid down, to give some account of the same function in the other classes of animals.

With regard to BIRDS, though, like other land-animals, they respire by means of lungs, Nature has enabled them to transmit air to almost every part of their bodies. The lungs of birds are so firmly attached to the diaphragm, the ribs, the sides, and the vertebrae, that they can admit of very little dilatation or contraction. Instead of being impervious, the substance of the lungs, as well as of the diaphragm, to which they adhere, is perforated with many holes or pa-

es for the transmission of air to the other parts of the body*. To each of these perforations a distinct membranous bag is joined. These bags are extremely thin and transparent. They extend through the whole of the abdomen, are attached to the back and sides of that cavity, and each of them receives air from their respective openings into the lungs. The cells in birds which receive air from the lungs are found not only in the soft parts, but in the bones. That ingenious and accurate anatomist, Mr. John Hunter of London, remarks, that the bones of birds which receive air are of two kinds :
‘ Some, as the sternum, ribs, and vertebrae, have their internal substance divided into innumerable cells, whilst others, ‘ as the os humeri and the os femoris, are hollowed out into ‘ one large canal, with sometimes a few bony columns running across at the extremities. Bones of this kind may be ‘ distinguished from those that do not receive air by certain ‘ marks : 1. By their less specific gravity : 2. By being less ‘ vascular, and therefore whiter : 3. By their containing lit- ‘ tle or no oil, and consequently being more easily cleaned, ‘ and, when cleaned, appearing much whiter than common ‘ bones : 4. By having no marrow, or even any bloody pul- ‘ py substance in their cells : 5. By not being, in general, so ‘ hard and firm as other bones ; and, 6. By the passage ‘ that allows the air to enter the bones, which can easily be ‘ perceived. In the recent bone we may readily discover ‘ holes, or openings, not filled with any such soft substance as ‘ blood-vessels or nerves ; and it happens that several of ‘ these holes are placed together, near the end of the bone ‘ which is next to the trunk of the bird ; and are distinguish- ‘ able by having their external edges rounded off ; which is ‘ not the case with the holes through which either nerves or ‘ blood-vessels pass into the substance of the bone†.

*This fact seems to have been first mentioned by the celebrated Doctor Harvey. See Harvey de Generat. Animal. Exercit. 3.

† Hunter's Observations on certain parts of the Animal Oeconomy, page 79.

Mr. Hunter afterwards informs us, that the lungs, at the anterior part, open into a number of membranous cells, which lie upon the sides of the pericardium, and communicate with those of the sternum. At the superior part, the lungs open into the large cells of a loose net-work, through which the wind-pipe, gullet, and large vessels, pass as they proceed to and from the heart. These cells, when distended with air, augment considerably the part where they are situated ; and this augmentation, or swelling, is generally a mark either of anger or of love. This tumefaction is remarkable in the turkey-cock, in the pouting pigeon, and in the breast of a goose when she cackles. These cells communicate with others in the axilla, under the large pectoral muscle. In most birds, the axillary cells communicate with the cavity of the os humeri by small openings in the hollow surface near the head of that bone. In some birds, these cells are continued down the wing, and communicate with the ulna and radius ; in others, they extend even to the pinions. The posterior edges of the lungs open into the cells of the vertebrae, into those of the ribs, the canal of the spinal marrow, the sacrum, and other bones of the pelvis ; from these parts the air finds a passage into the thigh-bone. ‘ Thus,’ continues our learned and indefatigable author, ‘ the cells of the abdomen, those surrounding the pericardium, those situated at the lower and forepart of the neck, and in the axilla, those in the cellular membrane under the pectoral muscles, as well as in that which unites the skin to the body, all communicate with the lungs, and are capable of being filled with air ; and again from these the cells of the sternum, ribs, vertebra of the back and loins, bones of the pelvis, the humeri, the ulna and radius, with the pinions and thigh-bones, can in many birds be furnished with air*.’

* Hunter’s Observations on certain parts of the Animal Economy, page 81

These facts, which our author candidly acknowledges had been formerly observed, led him, in the year 1758, to make experiments on the breathing of birds, in order to prove the free communication between the lungs and the several parts of the body mentioned above.

'First,' says he, 'I made an opening into the belly of a cock, and having introduced a silver canula, tied up the trachea; I found that the animal breathed by this opening, and might have lived; but, by an inflammation in the bowels coming on, adhesions were produced, and the communication cut off.'

'I next cut the wing through the os humeri, in another fowl, and tying up the trachea, as in the cock, found that the air passed to and from the lungs by the canal in this bone. The same experiment was made with the os femoris of a young hawk, and was attended with nearly the like success *.'

The extreme singularity of this almost universal diffusion of air through the bodies of birds, naturally excited a desire to discover what might be the intention of Nature in producing a structure so extraordinary. Mr. Hunter first imagined that it might be intended to assist the act of flying, by increasing the volume and strength of the animal, without adding to its weight, which must be diminished; because the specific gravity of the external air is superior to that of the internal air, which is rendered more rare by the heat of the animal's body. This opinion was corroborated, by considering that the feathers of birds, and particularly those of the wings, contain a great quantity of air. With his usual ingenuousness, however, Mr. Hunter, in opposition to his first conjecture, informs us, that the ostrich, which does not fly, was amply provided with air-cells dispersed through its body; that the wood-cock, and some other flying birds, were

* Ibid. page 82.

not so liberally supplied with these cells as the ostrich ; and that the bat had no such peculiarity of structure. With regard to the ostrich, though it is not intended to fly, it runs with amazing rapidity, and, consequently, requires similar resources of air.

He next conjectured, from analogy, that the air-cells in birds ought to be considered as an appendage to the lungs ; because in the snake, viper, and several other amphibious animals, the lungs are continued, in the form of two bags, through the whole abdomen, the upper part of which can only perform the office of respiration with any degree of effect ; because the lower part has comparatively few air-vessels. ‘The air,’ says Mr. Hunter, ‘must pass through this upper part before it gets to the lower in inspiration, and must also repass in expiration ; so that the respiratory surface has more air applied to it than what the lungs of themselves could contain. There is, in fact, a great similarity between birds and that class of animals called *amphibious* ; and, although a bird and a snake are not the same in the construction of the respiratory organs, yet the circumstance of the air passing in both beyond the lungs, into the cavity of the abdomen, naturally leads us to suppose, that a structure so similar is designed in each to answer a similar purpose. This analogy is still farther supported by the lungs in both consisting of large cells. Now, in amphibious animals, the use of such a conformation of lungs is evident ; for it is in consequence of this structure that they require to breathe less frequently than others. Even considering the matter in this light, it may still, in birds, have some connection with flying, as that motion may easily be imagined to render frequency of respiration inconvenient, and a reservoir of air may therefore become singularly useful. Although we are not to consider this structure in birds to be an extension of lungs, yet I can easily conceive this accumulation of

' air to be of great use in respiration ; for, as we observed in
' the viper, that the air, in its passage to and from these cells,
' must certainly have a considerable effect upon the blood in
' the lungs, by allowing a much greater quantity of air to
' pass in a given time, than if there was no such construction
' of parts. And this opinion will not appear to be ill founded,
' if we consider, that, both in the bird and the viper, the
' surface of the lungs is small in comparison to what it is in
' many other animals which have not this extension of cavity.
We must not, however, give up the idea of such structure
being of use in flying ; for I believe we may set it down
as a general rule, that, in the birds of longest and highest
flight, as eagles, this extension, or diffusion of air, is carried
farther than in the others ; and this opinion is strengthened,
by comparing this structure with the respiratory organs
in the flying insects, which are composed of cells diffused
through the whole body ; and these are extended
even into the head and down the extremities, while there
is no such structure in those that do not fly, as the spider, &c.

Though Mr. Hunter's modesty has not permitted him to draw his conclusion in a positive manner, he seems to have proved decidedly, that one use of the general diffusion of air through the bodies of birds is to prevent their respiration from being stopped or interrupted by the rapidity of their motion through a resisting medium. The resistance of the air increases in proportion to the celerity of the motion. Were it possible for man to move with a swiftness equal to that of a swallow, the resistance of the air, as he is not provided with internal reservoirs similar to those of birds, would soon suffocate him. Neither does the difficulty he mentions, with regard to the structure of the ostrich, seem to contradict his theory ; for though, as formerly remarked, the ostrich does not fly, he runs with astonishing rapidity.

The respiration of air is not only necessary to the existence of land-animals, but to that of FISHES of every denomination. Coetaceous fishes, or those of the whale-kind, respire, like man and quadrupeds, by means of lungs ; and, of course, they are obliged, at certain intervals, to come to the surface, in order to throw out the former air, and to take in a fresh supply.

Instead of lungs, the other species of fishes are furnished with gills, through which they respire both water and air ; for air is universally diffused or mixed with every portion of water. When a free communication with the external air is prevented by ice, or by artifice, fishes immediately discover symptoms of uneasiness, and soon perish. Ælian informs us, that, in winter, when the river Ister was frozen, the fishers dug holes in the ice ; that great numbers of fishes resorted to these holes ; and that their eagerness was so great, that they allowed themselves to be seized by the hands of the fishermen. Rondeletius made many experiments on this subject. If, says he, fishes are put into a narrow-mouthed vessel filled with water, and a communication with the air be preserved, the animals live, and swim about, not for days and months only, but for several years. If the mouth of the vessel, however, be so closely shut, either with the hand, or any other covering, that the passage of the air is excluded, the fishes suddenly die. Immediately after the mouth of the vessel is closed, the creatures rush tumultuously, one above another, to the top, contending which of them shall soonest receive the benefit of the air*. In the shallow parts of rivers, when frozen, many fishes are found dead. But, when parts of a river are deep or rapid, the fishes fly from the ice, and by this means avoid destruction.

These, and similar experiments, have been repeated by Mr. Willoughby, and many other authors ; and they have uni-

* Rondeletius, lib. 4. cap. 9.

formly been attended with the same event. A carp, in a large vessel full of water, was placed in the receiver of an air-pump. In proportion as the air was exhausted by working the pump, the surface of the animal's body was covered with a number of bubbles. The carp soon breathed quicker, and with more difficulty : A little after, it rose to the surface in quest of air. The bubbles on its surface next disappeared ; the belly, which before was greatly swollen, suddenly collapsed ; and the animal sunk to the bottom, and expired in convulsions.

Thus the respiration of air is as necessary to the existence of fishes as to that of land-animals ; for none of them can live long when deprived of this vivifying element. Fishes, indeed, seem to require a smaller quantity of air than animals who have a constant and free communication with the atmosphere. The bodies and fluids of fishes are colder than those of land-animals ; and, of course, if Doctor Crawford's theory be well founded, fishes require less air to support the proportionally small quantity of heat they possess.

An analogy between fishes and birds deserves here to be noticed. Both of these classes of animals are rapid in their motions ; and both of them, beside respiring by lungs or gills, have receptacles of air within their bodies. Fishes transmit small quantities of air through their gills ; but Nature has provided most of them with air-bags or bladders, which may answer the double purpose of enabling them to ascend and descend in the water, and to communicate a vital principle to their whole system.

We shall conclude this subject with an account of the modes employed by Nature for transmitting air into the bodies of INSECTS.

In this seemingly contemptible, and often noxious class of animals, Nature has exhibited a wonderful diversity of form, of manners, of instincts, of deformity, and of beauty. But,

however insignificant these creatures may appear to inattentive observers, Nature has been equally provident in the formation of their bodies, and in the means of preserving the different individuals, according to their kinds, as in the larger animals, which have the appearance of more importance in the scale of being. To insects she has denied lungs similar to those of men, quadrupeds, birds, and fishes ; but, as the transmission of air into their bodies was necessary to continue the principle of life, she has furnished them with peculiar instruments and apparatus for accomplishing this indispensable purpose.

Air is conveyed into the bodies of insects by instruments called *tracheae* or *stigmata*. The tracheae, or wind-pipes, are, in many insects, long tubes protruding externally from different parts of the body. In some, they proceed from the posterior part, and have the appearance of one, two, or three tails ; in others, they arise from the back or sides. The *stigmata* are small holes, generally of a different colour from the rest of the body, and run along the sides of many caterpillars in regular and beautifully dotted lines. That these tracheae and stigmata are destined for the transmission of air, has been proved by repeated experiments ; for, when stopped up by the application of oil, or other unctuous substances, the animals soon loose their existence.

In contemplating the parts of animals, when the uses of these parts are not apparent, we are apt to deceive ourselves by rashly supposing them to answer purposes for which they were never intended by Nature. Impressed with this idea, M. de Reaumur was not satisfied with the notion of Goedart and others, that the long tails of certain worms were intended to keep them steady in their motions, and to prevent them from rolling. Reaumur observed, that these worms or grubs could lengthen or shorten their tails at pleasure, but that they were always longer than the animal's body.

Because these tails have some resemblance to that of a rat, he distinguishes the animals by the name of *rat-tailed worms*. These worms are aquatic, and never appear on dry ground till they are about to undergo their first transformation. Reaumur, in order to observe their oeconomy more closely, collected a number of rat-tailed worms, and put them into a glass vessel filled two inches high with water. At first they were considerably agitated, each seemingly searching for a proper place of repose. Some of them swam across, others attached themselves to the sides, and others rested at the bottom of the vessel. In a quarter of an hour they were almost entirely tranquil, and Reaumur soon discovered the real use of their long tails. Upon examining the vessel, he found that each of the animals, in whatever situation they were placed, extended its tail exactly to the surface ; that, like other aquatic insects, the respiration of air was necessary to their existence ; and that the tail, which is tubular, and open at the extremity, was the organ by which this operation was performed. In this experiment, the distance from the bottom to the surface was two inches, and, of course, the tails were of an equal length. To discover how far the animals could extend their tails, this most ingenious and indefatigable philosopher gradually augmented the height of the water, and the tails uniformly rose to the surface till it was between five and six inches high. When the water was raised higher, the animals immediately quitted their station at the bottom, and either mounted higher in the water, or fixed upon the sides of the vessel, in situations which rendered it convenient for them to reach the surface with the points of their tails. These tails consist of two tubes, both of which are capable of extension and contraction. The first tube is always visible ; but the second, which is the proper organ of respiration, is exerted only when the water is raised to a certain height. Through this tube the air is conveyed into,

two large tracheae or wind-pipes within the body of the animal, and maintains the principle of life. When the tails are below the surface, they occasionally emit small bubbles of air, which are visible to the naked eye ; and immediately repair to the surface for fresh supplies. These rat-tailed worms pass the first and longest part of their lives under water ; when near the time of their transformation, they leave the water, go under the ground, and are there tranformed into chrysalids ; and, lastly, from this state they are transformed into flies, and spend the remainder of their existence in the air.

Another species of aquatic worms merit attention. They frequent marshes, ditches, and stagnating waters. Their general colour is a greenish brown. Their bodies consist of eleven rings ; and their skin is not crustaceous, but rather resembles parchment. Though these animals, before their transformation into flies, live in water, air is necessary to support their principle of life ; and the apparatus with which Nature has furnished them for that important purpose deserves our notice. The last ring, or termination of their bodies, is open, and serves as a conductor of air. From this last ring proceed a number of hairs, which, when examined by the microscope, are found to be real feathers with regular vanes. In particular situations, they bend the last ring in such a manner as to reach the surface of the water or mud in which they are placed. These feathers prevent the water from entering into the tube, or organ of respiration ; and, when the animal raises the termination of its body to the surface, in order to receive air, it erects and spreads the feathers, and by this means exposes the end of the tube to the atmosphere. When cautiously cut open, two large vessels, or tracheae, appear on each side, and occupy almost one half of the body. Both of these wind-pipes terminate in the open tube, or last ring. Though these worms are furnished

with organs of respiration, and actually respire air, yet M. de Reaumur discovered that some of them could live more than twenty-four hours without respiration.

So anxious is Nature to provide animals, in every state of their existence, with air, that, after the transformation of many insects into chrysalids, she creates instruments for that purpose, which did not exist previous to their transformation. The rat-tailed worms, formerly mentioned, soon after they are transformed into chrysalids, instead of a soft pliable skin, are covered with a hard crustaceous substance, seemingly impervious to the air; and the tail, which was the wind-pipe of the animal in its first state, gradually vanishes. In a few hours, however, four hollow horns shoot out, two from the fore, and two from the hind, part of what was the head of the animal. These horns, which are hard and tubular, M. de Reaumur discovered to be real wind-pipes, destined for the introduction of air into the chrysalis, a state in which the animals have the appearance of being almost totally dead, and, of course, should seem to have little use for respiration. He likewise discovered that these horns, which had pierced the hard exterior covering, terminated in as many tracheae in the body of the animal. This fact affords a strong example of the necessity of air for sustaining the principle of life, even in its lowest condition. After these animals pass from the chrysalis state to that of flies, they are deprived both of their tails and horns. But Nature, in this last stage of their existence, has not left them without proper resources for the introduction of air into their bodies. Instead of protuberant tracheae in the form of tails or horns, they now, like other flies, receive air by means of stigmata, or holes, variously disposed over different parts of the body.

The nymph of the libella, or dragon-fly, respire water, in the same manner as men and quadrupeds respire air. We receive and throw out the air by the mouth and nostrils.

But the nymphs of the libella receive and eject water by an aperture at the termination of their bodies. These nymphs sometimes throw out the water, at certain intervals, with such force, that the stream is perceptible at the distance of two or three inches from their bodies. When kept some time out of water, the desire or necessity of respiration is augmented ; and, accordingly, when replaced in a vessel filled with water, inspirations and respirations are repeated with unusual force and frequency. If you hold one of these nymphs in your hand, and apply drops of water to the posterior end of its body, it instantly, by an apparatus similar to the piston of a pump, sucks in the water, and the dimensions of its body are visibly augmented. This water is again quickly thrown out by the same instrument. But, though this insect respire water, air seems to be not the less necessary to its existence ; for, like other insects, the whole interior part of its body is amply provided with large and convoluted tracheæ ; and, externally, there are several stigmata destined for the introduction of air*.

The worms, or nymphs, of the ephemeron flies merit attention. They have received the denomination of *ephemeron*, because almost none of them survive the day in which they are transformed into flies. But many of them live not one hour after their transformation. When in the worm and nymph states, they generally live in holes near the surface of the water ; and, under these two forms, continue to grow till they are mature for passing into the last and shortest period of their existence. Swammerdam informs us, that some of them remain three years under water, others two, and others one only. During their abode in this element, they are nourished and prepared for their last and fatal change. Immediately after the males have joined their mates, and the females have deposited their eggs in the water, both perish,

* Reaumur, tom. 12. page 187. 12mo edition.

but not before they have left the rudiments of a numerous race of successors. As long as these insects live in the water, to inattentive observers, their general appearance is nearly the same. When they have passed, however, into nymphs, the vestiges of wings may be perceived, which we look for in vain during their first or worm state. In both states, the insect which is to become an ephemeron fly has six legs attached to the breast. The head is triangular, and from the base of each eye proceeds an articulated feeler. The body is composed of ten rings, from the last of which three tails, that probably perform the office of tracheae, arise. These tails, in some species, are as long as the animal's body, and are fringed with hairs which have a resemblance to feathers. But what principally deserves our notice on this subject is, that, on each side of the body, there are six or seven protuberances, which have the appearance of so many oars. With these instruments the animals describe arches in the water, first on one side, and then on the other, with astonishing rapidity. This circumstance led Clutius, and some other authors, to think that these protuberances were fins, or instruments of motion, and that the animals were fishes. But Reaumur remarked that they moved these fins with the same rapidity when the animals were at rest as when they were in motion ; and that, instead of fins, when examined by the microscope, he discovered them to be gills, through which the creatures respire. Each gill consists of a short trunk, and two large branches, or tubes, which give off on all sides a number of smaller ramifications, and are perfectly similar to the tracheae of other insects. At the origin of every gill, two tracheae penetrate the trunk, and are dispersed through the body of the animal.

Though the stigmata, or respiratory organs, of caterpillars and other insects, were long known to serve the purpose of inspiration, yet it was uncertain whether the animals respiration

by the same orifices, till Bonnet, and, after him, Reaumur, ascertained the fact by many curious and accurate experiments. The first of these authors immersed numbers of caterpillars, of different kinds, and at different times, in water, and he observed, both with the naked eye, and by the assistance of a glass, bubbles of air issuing from various parts of their bodies, and particularly from the stigmata. To remove all deception from his experiments before immersion, he carefully moistened the caterpillars with water, in order to dislodge any portions of the external air that might be adhering to their bodies. Some of them he allowed to remain so long under water, that they had every appearance of death. He then raised the head and the two anterior stigmata above the surface. The head, and first pair of legs, soon began to move from side to side; and the body necessarily partook of the same motions. During these movements, many bubbles of air issued from the posterior and intermediate stigmata, which still remained under water; but the membranous limbs continued nearly at rest. He next kept a caterpillar under water till all motion was suspended. Then he elevated the anus and the two last stigmata above the surface, that they might have a communication with the external air. He kept the animal in this situation about half an hour, without any symptoms of re-animation. After raising the body successively from the last to the first pair of stigmata, still the animal exhibited no symptoms of life; but, when he exposed the whole body to the external air for half an hour, the powers of life completely returned. After suspending the caterpillar about two hours with the last five pair of stigmata above the surface, he found that life was not extinguished. He then raised the water till the anus and last pair of stigmata only were exposed to the atmosphere. He allowed the caterpillar to remain in this situation more than half an hour; and he observed that it often bended its body with a view to

reach the surface, and that, during these efforts, bubbles of air issued from the anterior, but not from the posterior stigmata. He likewise remarked, that, on the smallest motion of the animal, these bubbles were discharged, but that they were augmented both in quantity and size, in proportion to the agitations of the body. M. Bonnet immediately raised the water till it covered the two last stigmata ; the caterpillar was violently agitated ; but no bubbles of air, the communication being cut off, appeared, and all motion ceased. He instantly lowered the water, and exposed the two posterior stigmata to the air ; the animal resumed its movements ; but in a moment after it expired. By another experiment, M. Bonnet discovered that a caterpillar lived eight days suspended in water, during all which time it breathed solely by the two posterior stigmata.

After these, and many other facts of a similar kind, which demonstrate that air is necessary for the support and continuation of animal life, it shall only be remarked, that, when caterpillars undergo their last change, and appear in the form of flies of every denomination, Nature has still furnished them with stigmata, or respiratory organs.

Reptiles of all kinds are likewise furnished with organs of respiration. Land-snails, at the approach of winter, bury themselves in the earth, or retire into holes of rocks, or of old buildings, where they remain in a torpid state during the severity of the season. For protection and warmth, these animals, when they go into their winter habitations, form, by means of a slime or saliva that issues from every pore of their bodies, a membranous cover which stops up the mouths of their shells. But this pellicle or cover, though apparently pretty hard and solid, is so thin and porous as not entirely to exclude the entrance of air, without which the principle of life could not be continued. Accordingly, when, by accident the pellicle is made too thick, and prevents a communi-

eration with the external air, the animal, to remedy the evil, makes a small aperture in its cover. In this state snails remain six or seven months, without food or motion, till the genial warmth of the spring breaks their slumber, and calls forth their active powers. Hence it should appear, that air is more necessary to the preservation of animal life than food itself ; for, in numberless instances, animals can live, not for days or weeks, but for months, without supplies of nourishment. None of them, however, are capable of existing nearly so long without having some communication with the air.

With regard to snails that live in fresh waters, or in the ocean, the species of which are numerous, their manner of respiring is singular. All of them have an aperture on the right side of the neck. This aperture serves the complicated purposes of discharging the faeces, of lodging the organs of generation, of ascending and descending in the water, and of respiration. They are frequently observed to straiten the orifice of this aperture, to stretch it out in the form of an oblong tube ; and, in this state, they rise to the surface, in order to expel the former air, and take in a new supply.

But, though air seems to be an indispensable principle of animal life, yet many animals can live longer without the use of this element, or at least with smaller quantities of it, than others. Even men, by long practice, acquire the faculty of retaining the air in their lungs for an almost incredible length of time. Some of those wretched creatures who are compelled by tyranny to dive for pearl-oysters, have been known to continue under water three quarters of an hour without receiving a fresh supply of air. Those animals which lie torpid during the winter, as the hedge-hog, the dormouse, the marmot, &c. though perhaps not entirely deprived of all communication with the air, exist, without any apparent

breathing, till the heat of the spring restores their wonted powers of life, when the respiration of air becomes again equally necessary as before their torpor commenced. The toad, like all the frog-kind, is torpid in winter. At the approach of winter, the toad retires to the hollow root of a tree, to the cleft of a rock, and sometimes to the bottom of a ditch or pond, where it remains for months in a state of seeming insensibility. In this last situation, it can have very little communication with the air. But still the principle of life, is continued, and the animal revives in the spring. What is more wonderful, toads have been found, in a hundred places of the globe, inclosed in the heart of solid rocks, and in the bodies of trees, where they have been supposed to exist for centuries, without any apparent access either to nourishment or to air ; and yet they were alive and vigorous. In the Memoirs of the Academy of Sciences for the year 1719, we have an account of a toad found alive, and healthy, in the heart of an old elm. Another, in the year 1731, was discovered, near Nantz, in the heart of an old oak, without any visible entrance to its habitation. From the size of the tree, it was concluded, that the animal must have been confined in that situation at least eighty or a hundred years. In the many examples of toads found in solid rocks, exact impressions of the animals bodies, corresponding to their respective sizes were uniformly left in the stones or trees from which they were dislodged ; and, to this day, it is said, that there is a marble chimney-piece at Chatsworth with a print of a toad in it ; and a traditionary account of the place and manner in which it was discovered.

These, and similar facts, are supported by authorities so numerous and so respectable, that it is unnecessary to quote them. Many abortive attempts have been made to account for an animal's growing and living very long in the situations above described, without the possibility of receiving nourish-

ment or air ; especially as, like all other animals, when put into an exhausted receiver, the toad soon loses its existence. Upon this subject I shall only hazard two observations. The toad, it is well known, when kept in a damp place, can live several months without food of any kind, though, in its state of natural liberty, it devours voraciously spiders, maggots, ants, and other insects. Here we have an instance, and there are many, of an animal whose constitution is so framed by Nature, that it can exist several months without receiving any portion of food. According to our ideas of the necessity of frequent supplies of nourishment, it is nearly as difficult for us to conceive an abstinence of four or six months as one of as many years, or even centuries. The one fact, therefore, though we are unable to account for either, may be as readily admitted as the other. The same remark is equally applicable to the regular respiration of air. The toad, and many other animals, from some peculiarity in their constitution, can live very long in a torpid state without seeming to respire, and yet their principle of life is not entirely extinguished. Hence the toad may, and actually does, live many years in situations which exclude a free intercourse with the external air. Besides, almost all the above, and similar facts, must, from their nature, have been discovered by common labourers, who are totally unqualified for examining every circumstance with the discerning eye of a philosopher. In rocks there are many chinks, as well as fissures, both horizontal and perpendicular ; and in old trees nothing is more frequent than holes and vacuities of different dimensions. Through these fissures and vacuities the eggs of toads may accidentally be conveyed by water, the penetration of which few substances are capable of resisting. After the eggs are hatched, the animals may receive moisture, and small portions of air, through the crevices of rocks, or the channels of aged trees. But I mean not to persuade ; for I cannot

satisfy myself. All I intend is to recommend, to those gentlemen who may hereafter chance to see such rare phenomena, a strict examination of every circumstance that can throw light on a subject so dark and mysterious ; for the vulgar, ever inclined to render uncommon appearances still more marvellous, are not to be trusted.

From the facts I have enumerated, it is apparent that air, in certain proportions, according to the structure and constitution of every animated being of which we have any knowledge, is indispensably necessary for the existence and continuation of animal life. Not only men, quadrupeds, birds, fishes, reptiles, and the larger insects, but even fleas, mites, the minute eels found in paste or in vinegar, and the animalcules produced by infusing animal or vegetable substances in water, inevitably perish when deprived of this all-vivifying element.

With regard to plants, air is so necessary to their existence, that they do not vegetate in an exhausted receiver. Plants, as formerly mentioned, are furnished with numerous air-vessels, or respiratory organs. They absorb and transmit air through every pore. When placed in an exhausted receiver, the air contained in every part of their substance is soon extracted ; and, in proportion as this air is likewise pumped out by the machine, the flowers and leaves show evident symptoms of debility ; they become flaccid, pendulous, and assume a sickly appearance ; and, if retained in that situation a certain length of time, their vegetating powers are irrecoverably extinguished.

Upon the whole, as the air we continually breathe is an universal menstruum, and, of course, liable to be impregnated with exhalations, from every substance to which it has access, the great importance of a personal, as well as of domestic cleanliness, is an obvious reflection. In building towns or houses, the situation, with regard to air, is a capital object,

The vicinity of marshes, of stagnating waters, of manufactures of tallow, oil, sal ammoniac, the smelting or corroding of metals of every kind, and many other operations which contaminate the air, should be either avoided or removed, as they are the pests of our senses, and the poisoners of our constitutions. Even in northern climates, houses surrounded with trees, or in the neighborhood of luxuriant vegetables, are always damp, and infested with insects ; and hence the ambient air is replete with the seeds of disease. Precautions of this kind are still more necessary in hot climates. Air, like other menstruum, absorbs a greater or less proportion of the particles of bodies, according to its degree of heat. In Madrid, however, in Constantinople, and in many other cities of warm regions, the houses are crowded together, the streets are narrow, and covered with filth of every kind. We cannot, therefore, be surprised, that human beings existing in such situations should be so frequently infected with pestilential diseases.

CHAPTER IV.

Of Motion.

MOTION, in the opinion of Aristotle, and the admirers of ancient philosophy, can only be produced by mind; and hence they define *mind* to be the *power of moving*. By the same mode of reasoning, it may be said that *rest*, or *inactivity*, is the *power of being moved*. But such speculations are foreign to the nature of this work, and perhaps fruitless in themselves. Though it is impossible to give an unexceptionable definition of motion, the phaenomenon itself is obvious to every man's senses.

All the terrestrial objects which present themselves to our observation are, with regard to motion, distinguishable into two general classes. The first consists of those which are endowed with a spontaneous or self-moving power, and with some qualities and affections similar to those of our minds. The second consists of all those objects in which no such qualities and affections appear, and are of a nature so passive, that they never move of themselves, nor, when put in motion, do they ever stop without some external influence or resistance. The first class of objects, from their possessing the power of spontaneous motion, and other qualities peculiar to animated beings, are easily distinguished from body, or matter, which is totally deprived of all these qualities. In consequence of its passive nature, matter not only never changes its state without external force, but resists when any such change is attempted to be made. When at rest, it cannot be put in motion without difficulty; and, when in motion, a certain force is required to stop its course. The force with which matter perseveres in its state, and resists

any change, is called its *vis inertiae*, and is always proportional to the quantity of matter in any particular body. When we double or triple a body, we uniformly find, that the force requisite to move it with equal celerity must likewise be doubled or tripled. These, and similar facts, which are results of perpetual experience, show that body is equally indifferent to motion and rest ; that this indifference seems to be the natural consequence of the most absolute inactivity ; and that the power of beginning motion is peculiar to active and intelligent beings. Leaving, therefore, all metaphysical speculations on this subject, we shall give some remarks upon the motions of animals.

In general, all the progressive motions of animals are performed by the instrumentality of muscles, tendons, and articulations. The operation of muscles depends upon some unknown influence derived to them from the brain and nerves. Hence the brain and nerves are the sources of every motion as well as of every sensation. With regard to the causes which determine the actions of animals, these must be referred to sensation, and the consequent exertions of intellect. The first impression an object makes upon our sensations stimulates us either to approach or retire from it, according as it excites affection or aversion. These motions necessarily result from the first impression made by the object. But man, and many other animals, have the power of resisting these original motives to action, and of remaining at rest, without either retiring or approaching. ‘If a man,’ says the Count de Buffon, ‘were deprived of sight, he would make no movement to gratify his eyes. The same thing would happen, if he were deprived of any of the other senses ; and, if deprived of every sense, he would remain perpetually at rest, and no object would excite him to move, though, by natural conformation, he were fully capable of motion.’ Natural wants, as that of taking nour-

ishment, necessarily excite desire or appetite. But, if a man be deprived of sensation, want cannot exist, because all its sources are annihilated. This is cutting off all the causes, and at the same time looking for the effects. An animal without some sensation is no animal, but a dead mass of matter. Sentiment is the only stimulus to animal motion ; the aptness of the parts produces the effect, which varies according to the structure and destination of these parts. The sense of want creates desire. Whenever an animal perceives an object fitted to supply its wants, desire is the necessary consequence, and action or motion instantly succeeds.

Beside progressive motion, the motion of hands, and other parts of animal bodies, which are all effected by means of muscles, and are subject to the will of the creatures who perform them, there are other motions that have little or no dependence on our inclinations. Of this kind are the action of the heart, the circulation of the blood, the digestion of food, the peristaltic motion of the bowels, the progress of the chyle from the stomach and intestines to the subclavian vein, the movement of the various secreted liquors, such as the gall, the urine, the saliva, &c. These, together with the action of the lungs in respiration, have received the denomination of *vital* and *involuntary motions*, because most of them go on without any conscious exertions of the intellectual principle. If such a variety of nice and complicated movements had been left to the determination and direction of our minds, they must necessarily have occupied too much of our attention ; and many of them would infallibly have been neglected during sleep, when consciousness is often almost totally suspended. But Nature in her operations is always wise. She has given to man, and other animals, the direction of no movements but what are easily performed, contribute to pleasure and health, and enable them to acquire food corresponding to the structure of their bodies and the elements in which they live.

It never was my intention, and, indeed, it would have been foreign to the design of this work, and ill suited to that class of mankind to whom I wish chiefly to be useful, to enter into the *rationale* of animal motion ; to mention the number, insertion, and direction, of the muscles employed in moving the different parts of animated bodies ; or to account for the modes by which animals walk, leap, fly, swim, creep, &c. Such discussions would not only require a volume, but a thorough acquaintance with all the depths of anatomical and mathematical knowledge. What follows, therefore, will consist of some desultory observations ; and the subject shall be concluded by enumerating a few examples of movements peculiar to certain animals.

The motions of animals are proportioned to their weight and structure. A flea can leap some hundred times its own length. Were an elephant, a camel, or a horse, to leap in the same proportion, their weight would crush them to atoms. The same remark is applicable to spiders, worms, and other insects. The softness of their texture, and the comparative smallness of their specific gravity, enable them to fall with impunity from heights that would prove fatal to larger and heavier animals.

Motion gives birth, perfection, death, and reproduction, to all animal and vegetable beings. It is the cause of all that diversity and change which perpetually affect every object in the universe. The globe we inhabit, as well as the innumerable and stupendous heavenly bodies which present themselves, in forms apparently minute to our observation, constantly exhibit motions of the most inconceivable rapidity. The magnitude of this earth, when considered with relation to man, and other animals, appears to be exceedingly great. It is indeed sufficiently spacious, and sufficiently prolific, for the conveniency and maintenance of its inhabitants. The magnificent objects displayed on its surface excite the

admiration of every beholder. Its plains and mountains, its rivers and lakes, its islands and continents, its seas and oceans, continually solicit attention, gratify curiosity, and call forth the powers of reason and reflection. But, when compared to the other heavenly bodies, the number and magnitude of which exceed all the powers of human conception, the grandeur of our earth diminishes. Instead of exciting wonder, it almost vanishes from our sight. Instead of an immense globe, it dwindles into a point, seems to occupy no space, and loses itself in the boundless regions of the universe. Considerations of this kind are apt to depress the dignity of man, and to lessen his importance in the great scale of being ; but they expand his mental faculties, and exalt his ideas concerning that inconceivable Power which first produced, and still supports, those astonishing orbs.

The different movements to which animals are stimulated by the desire of food, by love, by the appetite for frolic and exercise, by their hostilities, and by other exciting causes, give animation and vivacity to the whole scene of nature. A silent and motionless prospect, however beautiful and variegated, soon ceases to please, and at last becomes insupportable. Motion, says Mr. Harris, is the object or cause of all sensation. In music we hear it ; in favours we taste it ; in odors we smell it ; in touch we feel it ; in light we see it.

Animals furnished with destructive weapons, or endowed with uncommon strength, courage, or ingenuity, are proportionally slower in their movements than the weaker kinds. The same remark is applicable to those species whose food is always at hand. Worms, caterpillars, and many other insects, in order to procure nourishment, are under no necessity of taking an extensive range. But the motions of birds and fishes are extremely rapid ; because, in quest of food, they are obliged to pass through large tracks, and they have also many enemies to avoid.

Timid animals, as the hare, the rabbit, the Guiney-pig, &c. are almost perpetually in motion. Even when perfectly undisturbed, they are restless, and betray a continual anxiety of danger. They run about, stop short, erect their ears and listen. The Guiney-pig frequently raises itself on its hind-legs, and sniffs all around to catch the scent of food when hungry, or to increase its circle of hearing when afraid.

The movements of many animals are so extremely slow, that some of them, particularly those of the shell tribes, are generally supposed to be destitute of the power of moving. It is a common notion, that both fresh and salt water muscles have not the locomotive faculty. But this is a vulgar error. It is almost unnecessary to mention, that the exterior part of muscles consists of two shells hinged together, which the animals can open or shut at pleasure. Every person must likewise have observed, in the structure of the animal itself, a fleshy protuberance of a much redder colour, and denser consistence, than the other parts of the body. This muscular protuberance, which consists of two lobes, has been denominated a *trunk*, or *tongue*: But it is an instrument by which the creature is enabled to perform a progressive, though a very slow motion; and, therefore, in describing its manner of moving, I shall call these two lobes the animal's *tentacula*, or *feet*.

When inclined to remove from its present situation, the river-muscle opens its shell, thrusts out its tentacula, and, while lying on its side in an horizontal position, digs a small furrow in the sand. Into this furrow, by the operation of the same tentacula, the animal makes the shell fall, and thus brings it into a vertical position. We have now got our muscle on end; but how is he to proceed? He stretches forward his tentacula, by which he throws back the sand, lengthens the furrow, and this fulcrum enables him to proceed on his journey.

With regard to marine muscles, their progressive motion is performed in the same manner, and by the same instruments. When not in motion, they are all firmly attached to rocks, or small stones, by many threads of about two inches in length, which serve the double purposes of an anchor and cable. without this provision of Nature, these animals must become the sport of the waves, and the species would soon be annihilated. But, how does the creature spin these threads? A cylindrical canal extends from the origin to the extremity of the tentacula. In this canal an extremely glutinous substance is secreted, which the animal, by the operation of certain muscles, has the power of forcing out, and of attaching it, in the form of strong threads, to stones or other solid bodies. More than a hundred and fifty of these cables are often employed in mooring a single muscle *. The substance of the threads is exceedingly viscous, indigestible in the human stomach, and is probably the cause of those fatal consequences which sometimes happen to inattentive eaters. In Scotland, these threads are called the *beards* of muscles, and should be carefully pulled off before the animals are thrown into the stomach.

Other bivalved shell-fishes, the species of which are numerous, perform a progressive or retrograde motion by an instrument that has no small resemblance to a leg and foot. But the animals can, at pleasure, make this leg assume almost every kind of form, according as their exigencies may require. By this leg they are not only enabled to creep, to sink into the mud, or disengage themselves from it, but to perform a motion, which no man could suppose shell-fishes were capable of performing. When the tellina, or limpin, is about to make a spring, it puts the shell on the point or summit, as if with a view to diminish friction. It then stretches out the leg as far as possible, makes it embrace a portion of the shell,

* Oeuvres de Bonnet, tom. 5. pag. 361. 4to edit.

and, by a sudden movement, similar to that of a spring let loose, it strikes the earth with its leg, and actually leaps to a considerable distance *.

The spout-fish † has a bivalved shell, which resembles the handle of a razor. This animal is incapable of progressive motion on the surface ; but it digs a hole or cell in the sand, sometimes two feet in depth, in which it can ascend and descend at pleasure. The instrument or leg by which it performs all its movements is situated at the centre. This leg is fleshy, cylindrical, and pretty long. When necessary, the animal can make the termination of the leg assume the form of a ball. The spout-fish, when lying on the surface of the sand, and about to sink into it, extends its leg from the inferior end of the shell, and makes the extremity of it take on the form of a shovel, sharp on each side, and terminating in a point. With this instrument the animal cuts a hole in the sand. After the hole is made, it advances the leg still farther into the sand, makes it assume the form of a hook, and with this hook, as a fulcrum, it obliges the shell to descend into the hole. In this manner the animal operates till the shell totally disappears. When it chooses to regain the surface, it puts the termination of the leg into the shape of a ball, and makes an effort to extend the whole leg ; but the ball prevents any farther descent, and the muscular effort necessarily pushes the shell upward till it reaches the surface, or top of the hole. It is amazing with what dexterity and quickness these seemingly awkward motions are performed.

It is remarkable that the spout-fish, though it lives in salt water, abhors salt. When a little salt is thrown into the hole, the animal instantly quits his habitation. But it is still more remarkable, that, if you seize the animal with your hand, and afterwards allow it to retire into its cells you may strew as much salt upon it as you please, but the fish will never

* Oeuvres de Bonnet, tom. 5. pag. 341. 4to edit.

† The name of the animal in Scotland. In England it is called razor-fish.

again make its appearance. If you do not handle the animal, by applying salt, you may make it come to the surface as often as you incline ; and fishermen often make use of this stratagem. This behaviour indicates more sentiment and recollection than one should naturally expect from a spout-fish.

The scallop, another well known bivalved shell-fish, has the power of progressive motion upon land, and likewise of swimming on the surface of the water. When this animal happens to be deserted by the tide, it opens its shell to the full extent, then shuts it with a sudden jerk, by which it often rises five or six inches from the ground. In this manner it tumbles forward till it regains the water. When the sea is calm, troops, or little fleets of scallops, are often observed swimming on the surface. They raise one valve of their shell above the surface, which becomes a kind of sail, while the other remains under the water, and answers the purpose of an anchor, by steadyng the animal, and preventing its being overset. When an enemy approaches, they instantly shut their shells, plunge to the bottom, and the whole fleet disappears. By what means they are enabled to regain the surface, we are still ignorant.

With regard to the locomotive faculty of the oyster, the following facts are recorded in the *Journal de Physique* by the Abbé Dicquemare. Like many other bivalved shell-fish, the oyster has the power of squirting out water with a considerable force. By thus suddenly and forcibly ejecting a quantity of water, the animal repulses such enemies as endeavour to insinuate into its shell while open. By the same operation, if not firmly attached to rocks, to stones, or to one another, the oyster retreats backwards, or starts to a side in a lateral direction. Any person may amuse himself with the squirting and motions of oysters, by putting them in a plate situated in a horizontal position, and which contains as much

sea-water as is sufficient to cover them. The oyster has been represented by many authors as an animal destitute not only of motion, but of every species of sensation. The Abbé Dicquemare, however, has shown, that it can perform movements perfectly consonant to its wants, to the dangers it apprehends, and to the enemies by which it is attacked. Instead of being destitute of all sensation, oysters are capable of deriving knowledge from experience. When removed from situations which are constantly covered with the sea, devoid of experience, they open their shells, lose their water, and die in a few days. But, even when taken from similar situations, and laid down in places from which the sea occasionally retires, they feel the effects of the sun's rays, or of the cold air, or perhaps apprehend the attacks of enemies, and accordingly learn to keep their shells close till the tide returns. Conduct of this kind plainly indicates both sensation and a degree of intelligence.

The progressive motion of the sea-urching, or sea-egg, a well known multivalved shell-fish, merits our attention. This animal, of which there are several species, is round, oval, or shaped like a bias-bowl. The surface of the shell is divided into beautiful triangular compartments, and covered with numberless prickles ; from which last circumstance it has received the appellation of *sea-urchin*, or *sea-hedge-hog*. These triangles are separated by regular belts, and perforated by a great number of holes. Each hole gives lodgment to a fleshy horn similar to those of the snail, and susceptible of the same movements. Like the snail, the sea-urchin uses its horns when in motion ; but their principal use is to fix the animal to rocks, stones, or the bottom of the ocean. By means of the horns and prickles, which proceed from almost every point of the shell, the sea-urchin is enabled to walk either on its back or on its belly. The limbs it most generally employs are those which surround the mouth. But, when it chooses,

it can move forward, by turning on itself like the wheel of a coach. Thus the sea-urchin furnishes an example of an animal employing many thousand limbs in its various movements. The reader may try to conceive the number of muscles, of fibres, and of other apparatus, which are requisite to the progressive motion of this little animal.

The motion of that species of medusa, or sea-nettle, which attaches itself to rocks, and to the larger shell-fish, is extremely slow. The sea-nettles assume such a variety of figures, that it is impossible to describe them under any determinate shape. In general, their bodies have a resemblance to a truncated cone. The base of the cone is applied to the rock or other substance to which they adhere. With regard to colour, some of them are red, some greenish, some whitish, and others are brown. When the mouth, which is very large, is expanded, its margin is surrounded with a great number of fleshy filaments, or horns, similar to those of the snail. These horns are disposed in three rows around the mouth, and give the animal the appearance of a flower. Through each of these horns the sea-nettle squirts water, like so many jets-d'eau. What is peculiar in the structure of these creatures, the whole interior part of their body or cone, is one cavity or stomach. When searching for food, they extend their filaments, and entangle any small animals they encounter. When they meet with their prey, they instantly swallow it, and shut their mouths close like a purse. Though the animal should not exceed an inch, or an inch and a half, in diameter, as it is all mouth and stomach, it swallows large whelks and muscles. These shell-animals sometimes remain many days in the stomach before they are ejected. Their nutritive parts are at last, however, extracted; but how does the sea-nettle get quit of the shell? The creature has no other aperture in its body but the mouth, and this mouth is the instrument by which it both receives

nourishment, and discharges the excrement, or unprofitable part of its food. When the shell is not too large, the sea-nettle has the power of turning its inside out, and by this strange manoeuvre the shell is thrown out of the body, and the animal resumes its former state. But, when the shell presents itself in a wrong position, the animal cannot discharge it in the usual manner ; but, what is extremely singular, near the base of the cone, the body of the creature splits, as if a large wound had been made with a knife, and through this gash the shell of the muscle, or other shell, is ejected.

With regard to the progressive motion of the sea-nettle, it is as slow as the hour-hand of a clock. The whole external part of its body is furnished with numerous muscles. These muscles are tubular, and filled with a fluid, which makes them project in the form of prickles. By the instrumentality of these muscles, the animal is enabled to perform the very slow motion just now mentioned. But this is not the only means by which the sea-nettle is capable of moving. When it pleases, it can loosen the base of the cone by which it is attached to the rock, reverse its body, and employ the filaments round its mouth as so many limbs. Still, however, its movements are imperceptibly slow. For these facts several authors might be quoted ; but we shall refer the reader solely to M. de Bonnet *.

Before we conclude this chapter, we shall just mention a mode of flying which is peculiar to certain insects. The *mason-bee*, which is one of the solitary species, has received that appellation, because it constructs a nest with mud or mortar. Externally, this nest has no regular appearance ; and is, therefore, generally regarded as a piece of dirt accidentally adhering to a wall. This habitation, however unseemly in its exterior aspect, is furnished with regular cells, and often gives rise to great conflicts. When the real

* *Oeuvres de Bonnet*, 4to edit. tom. 5, page 345.

proprietor is abroad in quest of materials to finish the nest, a stranger takes possession. At meeting, a battle always ensues. This battle is fought in the air. Sometimes they fly with such rapidity and force against each other, that both parties fall to the ground. But, in general, like birds of prey, the one endeavours to rise above the other, and to give a downward blow. To avoid the stroke, the undermost, instead of flying forward or laterally, is frequently observed to fly backward. This retrograde flight is likewise performed occasionally by the common house-fly, and some other insects, though we are unable to perceive what stimulates them to employ this uncommon movement.

CHAPTER V.

Of the Instinct of Animals—Division of Instincts—Examples of Pure Instinct—Of such Instincts as can accommodate themselves to peculiar circumstances and situations—Of Instincts improveable by observation and experience—Some remarks and conclusions from this view of Instinct.

MANY theories have been invented with a view to explain the instinctive actions of animals; but none of them have received the general approbation of Philosophers. This want of success in the investigation of a subject so curious and so interesting must be owing to the operation of some powerful causes. Two of these causes appear to be a want of attention to the general oeconomy and manners of animals, and mistaken notions concerning the dignity of human nature. From perusing the compositions of most authors who have written upon animal instinct, it is evident, that they have chiefly derived their ideas, not from the various mental qualities discoverable in different species of animals, but from the feelings and propensities of their own minds. Some of them, at the same time, are so averse to allow brutes a participation of that intellect which man possesses in such an eminent degree, that they consider every animal action to be the result of pure mechanism. But the great source of error on this subject is the uniform attempt to distinguish instinctive from rational motives. I shall, however, endeavour to show that no such distinction exists, and that the reasoning faculty itself is a necessary result of instinct.

The proper method of investigating subjects of this kind, is to collect and arrange the facts which have been discovered, and to consider whether these facts lead to any general conclusions. This method I have adopted; and shall there-

fore exhibit examples of pure instincts ; of such instincts as can accommodate themselves to peculiar circumstances and situations ; and of instincts improveable by observation and experience. In the last place, I shall draw some conclusions.

I. *Of Pure Instincts.*

By *pure* instincts, I mean those, which, independent of all instruction or experience, instantaneously produce certain actions when particular objects are presented to animals, or when they are influenced by peculiar feelings. Of this class the following are examples.

In the human species, the instinct of sucking is exerted immediately after birth. This instinct is not excited by any smell peculiar to the mother, to milk, or to any other substance ; for infants suck indiscriminately every thing brought into contact with their mouths. The desire of sucking, therefore, is innate, and coeval with the appetite for air.

The voiding of urine and excrement, sneezing, retraction of the muscles upon the application of any painful stimulus, the moving of the eye-lids, and other parts of the body, are likewise effects of original instincts, and essential to the existence of young animals.

The love of light is exhibited by infants at a very early period. I have remarked evident symptoms of this attachment on the third day after birth. When children are farther advanced, marks of the various passions gradually appear. The passion of fear is discoverable at the age of two months. It is called forth by approaching the hand to the child's eye, and by any sudden motion or unusual noise. I once instituted a course of experiments to ascertain the periods when the various passions, principles, or propensities, of the human mind are unfolded, and to mark the causes which first produced them. But, in less than five months after the

birth of the child, the business became too complicated and extensive for the time I had to bestow on subjects of this nature.

The brute creation affords innumerable examples of pure instincts.

When caterpillars are shaken off a tree in every direction, all of them instantly turn toward the trunk, and climb up, though they had never formerly been on the surface of the ground.

Young birds open their mouths upon hearing any kind of noise, as well as that of their mother's voice. They have no apprehensions of harm; neither do they offer to use their wings till they acquire more strength and experience. The lion's cub is not ferocious till he feels force and activity for destruction.

Insects invariably deposit their eggs in situations most favourable for hatching and affording nourishment to their future progeny. Butterflies, and other insects, whose offspring feed upon vegetables, uniformly fix their eggs upon such plants as are most agreeable to the palate and constitution of their young. Water insects never deposit their eggs on dry ground. I have seen butterflies which had been transformed in the house exhibit marks of the greatest uneasiness because they could not find a proper nidus for their eggs; and, when every other resource failed, they pasted the eggs on the panes of the window.

Some species of animals look not to future wants. Others, as the bee and the beaver, are endowed with an instinct which has the appearance of foresight. They construct magazines, and fill them with provisions.

The common bees attend the female, or queen, do her many little services, and even feed her with honey from their trunks*. When deprived of the female, all their la-

* Reaumur, 12mo edit. vol. 9. page 300.

bours cease†, till a new one is obtained, whom they treat with much respect, and renew their usual operations ‡. They make cells of three different dimensions, for holding workers, drones, and females ; and the queen-bee, in depositing her eggs, distinguishes the three different kinds, and never puts a royal or a drone egg into the cells destined for the reception of the working bees. What is equally singular, the number of these cells is proportioned to that of the different bees to be produced. One royal cell weighs as much as one hundred of the common kind §. When there are several females in a hive, the bees work little till they have destroyed all the females but one. If more than a single female were allowed to remain in a hive, a greater number of eggs would be laid than the working bees are able to make cells for receiving them.

The wood-piercing bee, which is one of the solitary species, gnaws with amazing dexterity and perseverance, a large hole in old timber. After laying her eggs in the cells, she deposits such a quantity of glutinous matter as nourishes the worms produced from these eggs till the time of their transformation into flies. She then pastes up the mouth of the hole, and leaves her future offspring to the provision she has made for them.

The bees of that species which build cylindrical nests with rose-leaves, exhibit a very peculiar instinct. They first dig a cylindrical hole in the earth. When that operation is finished, they go in quest of rose-bushes ; and, after selecting leaves proper for their purpose, they cut oblong, curved, and even round pieces, exactly suited to form the different parts of the cylinder||.

The solitary wasp digs holes in the sand. In each hole she deposits an egg. But how is the worm, after it is hatched, to be nourished ? Here the instinct of the mother merits

† Ibid. page 320.

§ Ibid. tom. 10. page 124.

‡ Ibid. page 340.

|| Reaumur, tom. 11. page 138.

attention. Though she feeds not upon flesh herself, and certainly knows not that an animal is to proceed from the egg, and far less that this animal must be nourished with other animals, she collects ten or twelve small green worms, which she piles one above another, rolls them up in a circular form, and fixes them in the hole in such a manner that they cannot move. When the wasp-worm is hatched, it is amply stored with the food Nature has destined for its support. The green worms are devoured in succession*; and the number deposited is exactly proportioned to the time necessary for the growth and transformation of the wasp-worm into a fly, when it issues from the hole, and is capable of procuring its own nourishment†.

There are many other instances of ichneumon wasps and flies, which, though they feed not themselves upon worms, lay up provisions of these animals for the nourishment of their young; and each kind is adapted to the constitution of the worm that is to proceed from their eggs ‡.

Birds of the same species, unless when restrained by peculiar circumstances, uniformly build their nests of the same materials, and in the same form and situation, though they inhabit very different climates. When removed by necessity from their eggs, they hasten back to them with anxiety. They turn and shift their eggs, which has the effect of heating them equally. Ducks and geese cover up their eggs till they return to the nest. A hen sits with equal ardour upon eggs of a different species, or even upon artificial eggs. I have often contemplated with wonder an instinct of the swallow. When her offspring are very young, like other small birds, she carries their excrements out of the nest. But, after they are older, she attaches herself to the side of the nest, and, by some gestures and sounds, solicits the young to void

* Reaumur, tom. 12. page 18.

† Ibid. page 22—32.

‡ Reaumur, tom. 11. pag. 38

their excrements : One of them immediately turns round, elevates its hind parts above the edge of the nest, makes the proper effort, and the mother, before the dung is half protruded from the anus, lays hold of it with her bill, drags it out, carries it off, and drops it at a distance from the nest. In all these operations, men recognise the intentions of Nature ; but they are hid from the animals who perform them.

The spider, the dermestes, and many insects of the beetle kind, exhibit an instinct of a very uncommon nature. When put in terror by a touch of the finger, the spider runs off with great swiftness : But, if he finds, that, whatever direction he takes, he is opposed by another finger, he then seems to despair of being able to escape, contracts his limbs and body, lies perfectly motionless, and counterfeits every symptom of death. In this situation I have pierced spiders with pins, and torn them to pieces, without their discovering the smallest mark of pain. This simulation of death has been ascribed to a strong convulsion, or stupor, occasioned by terror. But this solution of the phaenomenon is erroneous. I have repeatedly tried the experiment, and uniformly found, that, if the object of terror be removed, in a few seconds the animal runs off with great rapidity. Some beetles, when counterfeiting death, suffer themselves to be gradually roasted, without moving a single joint.

It is unnecessary to give more examples of pure instincts. I shall therefore proceed to the second class, namely,

II. *Of Instincts which can accommodate themselves to peculiar circumstances and situations.*

To this class many human instincts may be referred. But, as these instinctive propensities are likewise highly improveable by experience and observation, examples of them will fall more naturally to be given under the third class.

Those animals are most perfect whose sphere of knowledge extends to the greatest number of objects. When interrupted in their operations, they know how to resume their labours, and to accomplish their purposes by different means. Some animals have no other power but that of contracting or extending their bodies. But the falcon, the dog, and the fox, pursue their prey with intelligence and address.

The ostrich has been accused of unnaturalness, because she leaves her eggs to be hatched by the heat of the sun. In Senegal, where the heat is great, she neglects her eggs during the day, but sits upon them in the night. At the Cape of Good Hope, however, where the degree of heat is less, the ostrich, like other birds, sits upon her eggs both day and night.

Rabbits dig holes in the ground for warmth and protection. But, after continuing long in a domestic state, that resource being unnecessary, they seldom employ this art *.

Bees, when they have not room enough for their operations, augment the depth of their honey-cells †. The female bee, when the cells are not sufficiently numerous to receive her eggs, lays two or three in each cell. But, a few days after, when the cells are increased, the working bees remove all the supernumerary eggs, and deposit them in the new constructed cells ‡.

When a wasp, in attempting to transport a dead companion from the nest, finds the load too heavy, he cuts off its head, and carries it out in two portions ||.

In countries infested with monkeys, many birds, which, in other climates, build in bushes and the clefts of trees, suspend their nests upon slender twigs, and, by this ingenious device, elude the rapacity of their enemies.

The nymphs of water-moths, commonly called *cod-bait*, cover themselves, by means of gluten, with pieces of wood,

* Gazette Liter. tom. 3. pag. 228.
† Ibid. pag. 240,

‡ Reaumur, tom. 10. pag. 29.
|| Ibid. tom. 11. pag. 241.

straw, small shells, or gravel. It is necessary that they should always be nearly in equilibrium with the water in which they live. To accomplish this purpose, when their habitations are too heavy, they add a piece of wood, when too light a bit of gravel *.

I had a cat that frequented a closet, the door of which was fastened by a common iron latch. A window was situated near the door. When the door was shut, the cat gave herself no uneasiness. As soon as she tired of her confinement, she mounted on the sole of the window, and with her paw dexterously lifted the latch and came out. This practise she continued for years.

These examples, I hope, are sufficient.

III. *The third class comprehends all those Instincts which are improveable by experience and observation.*

The superiority of man over the other animals seems to depend chiefly on the great number of instincts with which his mind is endowed. Traces of every instinct he possesses are discoverable in the brute creation. But no particular species enjoys the whole. On the contrary, most animals are limited to a small number. This appears to be the reason why the instincts of brutes are stronger, and more steady in their operation, than those of man. A being actuated by a great variety of motives must necessarily reason, or, in other words, hesitate in his choice. Its conduct, therefore, must often waver; and he will have the appearance of being inferior to another creature who is stimulated to action by a smaller number of motives. Man, accordingly, has been considered as the most vacillant and inconsistent of all animals. The remark is just; but, instead of a censure, it is an encomium on the species. The actions of a dog, or a monkey, for the same reason, are more various, whimsical, and uncertain, than those of a sheep or a cow.

* Bonnet, tom. 4. page. 209.—Reaumur, tom. 5. pag. 215.

Most human instincts receive improvement from experience and observation, and are capable of a thousand modifications. This is another source of man's superiority over the brutes. When we are stimulated by a particular instinct, instead of instantly obeying the impulse, another instinct arises in opposition, creates hesitation, and often totally extinguishes the original motive to action. The instinct of fear is daily counteracted by ambition or resentment; and, in some minds, fear is too powerful for resentment, or any other instinct we possess. The instinct of anger is often restrained by the apprehension of danger, by the sense of propriety, by contempt, and even by compassion. Sympathy, which is one of our most amiable instincts, frequently yields to anger, ambition, and other motives. The instinct or sense of morality is too often thwarted by ambition, resentment, love, fear, and several of what I call modified or compounded instincts, such as avarice, envy, &c.

The following are examples of modified, compounded, or extended instincts.

Superstition is the instinct of fear extended to imaginary objects of terror.

Devotion is an extension of the instinct of love to the First Cause, or Author of the Universe.

Reverence or respect for eminent characters is a species of devotion.

Avarice is the instinct of love directed to an improper object.

Hope is the instinct of love directed to future good.

Envy is compounded of love, avarice, ambition, and fear.

Benevolence is the instinct of love diffused over all animated beings.

Sympathy is the instinct of fear transferred to another person, and reflected back upon ourselves.

In this manner, all the modified, compounded, or extended passions and propensities of the human mind, may be traced back to their original instincts.

The instincts of brutes are likewise improved by observation and experience. A young dog, like a child, requires both time and art to unfold and perfect his natural instincts. If neglected by man, he learns from his companions how to act in particular situations : But, when he enjoys both these sources of information, his talents are improved to a degree that often excites our astonishment. The same remark applies to all docile animals, as the elephant, the horse, the camel, &c. Every man's recollection will supply him with many examples of the improveable talents of brutes ; and, therefore, it is unnecessary to be more explicit.

Having exhibited instances of pure instinct, of instincts which accommodate themselves to peculiar circumstances and situations, and of instincts improveable by observation and experience, I shall now hazard a few remarks.

From the examples I have given, it appears that instinct is an original quality of mind, which, in many animals, may be improved, modified, and extended, by experience ; that some instincts are coeval with birth ; and that others, as fear, anger, the principle of imitation, and the power of reasoning, or balancing motives, are gradually unfolded, according to the exigencies of the animal. One of the strongest instincts appears not till near the age of puberty ; but, by bad example, and improper situations, this instinctive desire is often prematurely excited. The minds of brutes, as well as those of men, have original qualities, destined for the preservation of the individual and the continuation of the species. The calling forth of these qualities is not extinct, but the exertion or energy of instinct. Instincts exist before they act. What man or brutes learn by experience, though this experience be founded on instinct, cannot with propriety be called in-

ftinctive knowledge, but knowledge derived from experience and observation. Instinct should be limited to such actions as every individual of a species exerts without the aid either of experience or imitation. Hence instinct may be defined, ‘Every original quality of mind which produces particular feelings or actions, when the proper objects are presented to it.’ These qualities or instincts vary in particular species. Some are endowed with many, and others with few. In some they are stronger, in others weaker ; and their strength or weakness seems to be exactly proportioned to their number. The difference of talents among men who have had the same culture, arises from a bluntness, or absolute deprivation of some original or modified instincts. Taste, or love of particular objects, whether animated, inanimated, or artificial, is in some men so obtuse, that we often say it is entirely wanting. Insects have fewer instincts than men or quadrupeds ; but the exertions of insects are so uniform and steady, that they excite the admiration of every beholder.

Sensation implies a sentient principle or mind. Whatever feels, therefore, is mind. Of course, the lowest species of animals are endowed with mind : But the minds of animals have very different powers ; and these powers are expressed by peculiar actions. The structure of their bodies is uniformly adapted to the powers of their minds. We never see a mature animal attempting actions which Nature has not enabled it to perform, by bestowing on it proper instruments. A bee collects the materials of honey and wax, but attempts not to gnaw rotten wood, like the wasp. Neither does peculiarity of structure prompt the actions of brutes. Calves push with their heads long before their horns are grown. This, and similar examples, shew, that the instincts of brutes exist previous to the expansion of those instruments which Nature intended they should employ.

This view of instinct is simple, removes every objection to the existence of mind in brutes, and unfolds all their actions, by referring them to motives perfectly similar to those by which man is actuated. There is, perhaps, a greater difference between the mental powers of some animals than between those of man and the most sagacious brutes. Instincts may be considered as so many internal senses, of which some animals have a greater, and others a smaller number. These senses, in different species, are likewise more or less ductile; and the animals possessing them are, of course, more or less susceptible of improving, and of acquiring knowledge.

The notion that animals are machines, is perhaps too absurd to merit refutation. Though no animal is endowed with mental powers equal to those of man, yet there is not a faculty of the human mind, but evident marks of its existence are to be found in particular animals. Senses, memory, imagination, the principle of imitation, curiosity, cunning, ingenuity, devotion, or respect for superiors, gratitude, are all discoverable in the brute creation. Neither is art denied to them. They build in various styles; they dig; they wage war; they extract peculiar substances from water, from plants, from the earth; they modulate their voices so as to communicate their wants, their sentiments, their pleasures and pains, their apprehensions of danger, and their prospects of future good. Every species has its own language, which is perfectly understood by the individuals. They ask and give assistance to each other. They speak of their necessities; and this branch of their language is more or less extended, in proportion to the number of their wants. Gestures and inarticulate sounds are the signs of their thoughts. It is necessary that the same sentiments should produce the same sounds and the same movements; and, consequently, each individual of a species must have the same organization. Birds and quadrupeds, accordingly, are incapable of holding discourse to each

other, or communicating the ideas and feelings they posseß in common. The language of gesture prepares for that of articulation ; and some animals are capable of acquiring a knowledge of articulate sounds. They first judge of our thoughts by our gestures ; and afterwards acquire the habit of connecting these thoughts with the language in which we express them. It is in this manner that the elephant and the dog learn to obey the commands of their masters.

Infants are exactly in the same condition with brutes. They understand some of our gestures and words long before they can articulate. They discover their wants by gestures and inarticulate sounds, the meaning of which the nurse learns by experience. Different infants have different modes of expressing their wants. This is the reason why nurses know the intentions of infants, though they are perfectly unintelligible to strangers. When an infant, accordingly is transferred from one nurse to another, the former instructs the latter in the gestures and inarticulate language of the child.

The idea of a *machine* implies a select combination of the common properties of matter. The regularity of its movements is a proof that they are totally distinct from animal or spontaneous motion. A machine has nothing analogous to sensation, which is the lowest characteristic of an animal. An *animated machine*, therefore, is an absurd abuse of terms. It confounds what Nature has distinguished in the most unambiguous manner. The instincts of brutes are, in general, stronger, and less subject to restraint, than those of man. The reason is plain : They have not an equal number of instincts to curb, counterbalance, or moderate their motives to particular actions. Hence they have often the appearance of acting by mere impulse ; and this circumstance has led some philosophers to consider brutes as machines. But they reflect not that children, savages, and ignorant men, act nearly

in the same manner. It is society and culture which soften and moderate the passions and actions of men, as well as those of docile animals.

Brutes, like men, learn, to see objects in their proper position, to judge of distances and heights, and of hurtful, pleasureable, or indifferent bodies. Without some portion of reason, therefore, they could never acquire the faculty of making a proper use of their senses. A dog, though puffed with hunger, will not seize a piece of meat in presence of his master, unless it be given to him : But, with his eyes, his movements, and his voice, he makes the most humble and expressive petition. If this balancing of motives be not reasoning, I know not by what other name it can be called.

Animals, recently after birth, know not how to avoid danger. Neither can they make a proper use of their members. But experience soon teaches them what is pleasant and what is painful, what objects are hurtful and what salutary. A young cat, or a dog, who has had no experience of leaping from a height, will without hesitation, precipitate itself from the top of a high wall. But, after perceiving that certain heights are hurtful, and other's inoffensive, the animal learns to make the distinction, and never afterwards can be prevailed upon to leap from a height which it knows will be productive of pain.

Young animals examine every object they meet with. In this investigation they employ all their organs. The first periods of their life are dedicated to study. When they run about, and make frolicsome gambols, it is Nature sporting with them for their instruction. In this manner they improve their faculties and organs, and acquire an intimate knowledge of the objects which surround them. Men who, from peculiar circumstances, have been prevented from mingling with companions, and engaging in the different amusements and exercises of youth, are always awkward in

their movements, cannot use their organs with ease or dexterity, and often continue, during life, ignorant of the most common objects.

From the above facts and reasoning, it seems to be apparent, that instincts are original qualities of mind ; that every animal is possessed of some of these qualities ; that the intelligence and resources of animals are proportioned to the number of instincts with which their minds are endowed ; that all animals are, in some measure, rational beings ; and that the dignity and superiority of the human intellect are necessary results, not of the conformation of our bodies, but of the great variety of instincts which Nature has been pleased to confer on the species.

CHAPTER VI.

Of the Senses.

NO animal of which we have any knowledge is endowed with more than the five external senses of smelling, tasting, hearing, touch, and seeing; and no animal, however, imperfect, is destitute of the whole. Without organs of sensation, in a smaller or greater number, animal or intellectual existence is to us an inconceivable idea. Hence the notion of the ancients, and of a very few moderns, that this earth, as well as all the heavenly bodies, are intelligent beings, though they have not the vestige of any instrument of sensation, or of any thing analogous to our ideas of animation, except mechanical motion, is too absurd even to be seriously mentioned.

Upon this interesting subject, as it comprehends every source of information, and every motive to action in man, as well as in the inferior animals, it is not surprising that so much has been written, and that so many different theories have been invented, and submitted to public inspection. Some of these theories shall be taken notice of in a cursory manner, and others, as unworthy of attention, shall be passed over in silence.

Our observations on the different instruments of sensation shall proceed in the following order, namely, of the senses of smelling, of tasting, of hearing, of touch, and of seeing. In general, it may be remarked, that all sensation is conveyed to the mind by an unknown influence of the nerves. If the optic, olfactory, or any nerve distributed over an organ of sensation, be cut, or rendered paralytic, the animal instantly loses that particular sense. This is a fact universally established by experiment. But that the nerves, which are per-

factly similar in every part of the body, should, when distributed over the eye, the ear, the tongue, the nose, convey to the mind feelings so different, is the most mysterious part of this subject. When M. de Bonnet tells us, that every organ of sense probably consists of fibres specifically different ; and that these fibres are particular senses endowed with a peculiar manner of acting, corresponding to the perceptions they excite in the mind ; he means to reason ; but he does no more than give a circumlocution for the fact.

OF SMELLING.

IN man, and many other animals, the organ by which the sense of smelling is conveyed to the mind, has received the general appellation of *nose*, or *nostrils*. The more immediate instrument of this sensation is a soft, vascular, porous membrane, covered with numerous papillae, and is known by the name of *membrana pituitaria*, or *membrana Schneideriana*. This membrane is totally covered with infinite ramifications and convolutions of the olfactory nerves. These nerves are almost naked, and exposed to the action of the air which passes through the nose in performing the function of respiration. But Nature, ever attentive to the ease and convenience of her creatures, has furnished the nostrils with a number of glands, or small arteries, which secrete a thick insipid mucus. By this mucus, the olfactory nerves are defended from the action of the air, and from the painful stimuli of acrid odours.

The odours perceived by smelling are extremely various. Some of them convey to us the most delightful and refreshing sensations, and others are painful, noxious, and disgusting. All bodies in Nature, whether solid or fluid, whether animated or inanimated, continually send forth to the air certain effluvia or emanations from their respective substances. These effluvia float in the atmosphere, and act upon

the olfactory nerves of different animals, and sometimes of different individuals of the same species, in such a manner as to produce very different sensations. What is pleasant to the nostrils of one animal is highly offensive to those of another. Brute animals select their food chiefly by employing the sense of smelling, and it seldom deceives them. They easily distinguish noxious from salutary food ; and they carefully avoid the one, and use the other for nourishment. The same thing happens with regard to the drink of animals. A cow, when it can be obtained, always repairs to the clearest and freshest streams ; but a horse, from some instinctive impulse, uniformly raises the mud with his feet, and renders the water impure, before he drinks.

In the selection of food, men are greatly assisted, even in the most luxurious state of society, by the sense of smelling. By smelling we often reject food as noxious, and will not risk the other test of tasting. Victuals which have a putrid smell, as equally offensive to our nostrils as hurtful to our constitutions, we avoid with abhorrence ; but we are allured to eat substances which have a grateful and savoury odour. The more frequent and more acute discernment of brutes in the exercise of this sense, is entirely owing to their freedom, and to their using natural productions alone. But men in society, by the arts of cookery, by the unnatural assemblage of twenty ingredients in one dish, blunt, corrupt, and deceive both their senses of smelling and of tasting. Were we in the same natural condition as the brutes, our sense of smelling would enable us to distinguish, with equal certainty, noxious from salutary food. Brutes, as well as men, prefer particular foods to others. This may be considered as a species of luxury ; but it should likewise be considered, that all the articles they use are either animal or vegetable substances in a natural state, neither converted into a thousand forms and qualities by the operation of fire and water, nor having their favour exalted by stimulating condiments. Do-

mestic animals are nearly in the same condition with luxurious men. A pampered dog sniffs and rejects many kinds of food, which, in a natural state, he would devour with eagerness.

It is not unworthy of remark, that, in all animals, the organs of smelling and of tasting are uniformly situated very near each other. Here the intention of Nature is evident. The vicinity of these two senses forms a double guard in the selection of food. Were they placed in distant parts of the body, they could not so readily give mutual aid to one another.

But assistance in the choice of food is not the only advantage that men and other animals derive from the sense of smelling. Every body in nature, whether animal, vegetable, or mineral, when exposed to the air, continually sends forth emanations, or effluvia, of such extreme subtlety, that no eye can perceive them. These effluvia, or volatile particles, diffuse themselves through the air, and most of them are recognized, by the organ of smelling, to be either agreeable or disagreeable. To give some idea of the inconceivable minuteness of these particles, and of the amazing sensibility of the nostrils of animals, the odour of musk has been known to fill a large space for several years without losing any perceptible part of its weight. Thus, the air we breathe is perpetually impregnated with an infinity of different particles which stimulate the olfactory nerves, and give rise to the sensation of smell. When our senses are not vitiated by unnatural habits, they are not only faithful monitors of danger, but convey to us the most exquisite pleasures. Even the sense of smelling is always productive either of pleasure or pain. The fragrance of a rose, and of many other flowers, is not only pleasant, but gives a refreshing and delightful stimulus to the whole system, and may be considered as a species of wholesome nourishment ; while the odours pro-

ceeding from hemlock, and from many other noxious vegetable, animal, and mineral substances, are highly offensive to our nostrils. Hence we are naturally compelled to embrace the one class of sensations and to avoid the other.

Some animals, as the dog, the fox, the raven, &c. are endowed with a most exquisite sense of smelling. A dog scents various kinds of game at considerable distances ; and, if the fact were not confirmed by daily experience, it could hardly gain credit, that he can trace the odour of his master's foot through all the winding streets of a populous city. If we judge from our own feelings, this extreme sensibility in the nose of a dog is to us perfectly incomprehensible.

The sense of smelling, like that of some other senses, may be perverted or corrupted by habit. The snuffing, chewing, and smoking tobacco, though at first disagreeable, become, by the power of habit, not only pleasant, but almost indispensable. The same remark is applicable to the practice of swallowing ardent spirits, the most deleterious of all poisons, because the most extensively employed. How the natural state of the nerves, and of the sensations conveyed by them, should be so completely changed, we are totally ignorant. The constitution of the nerves often varies in different individuals of the same species. An odour which is disgusting to one man is highly grateful to another. I knew a gentleman who was in the daily habit of lighting and putting out candles, that he might enjoy the pleasure of their smell. Few men, I suppose, would envy him.

OF TASTING.

THE tongue and palate are the great instruments of this sensation. With much wisdom and propriety the organ of taste is situated in such a manner as enables it to be a guardian to the alimentary canal, and to assist the organ of smell in distinguishing salutary from noxious food. The tongue,

like the other instruments of sensation, is amply supplied with nerves. The terminations of these nerves appear on the surface of the tongue in the form of *papillae* or minute nipples, which are always erected on the application of sapid or stimulating substances. This elevation and extention of the papillae, by bringing larger portions of the nerves into contact with the substances applied to the tongue, give additional strength to the sensation, and enable us to judge with greater accuracy concerning their nature and qualities. Beside the nervous papillae, the tongue is perpetually moistened with saliva, a liquor which, though insipid itself, is one great cause of all tastes. The saliva of animals is a very powerful solvent. Every substance applied to the tongue is partially dissolved by the saliva before the sensation of taste is excited. When the tongue is rendered dry by disease, or any other cause, the sense of taste is either vitiated or totally annihilated.

In some men, the sense of taste is so blunt, that they cannot distinguish with any degree of accuracy the different species of that sensation. In others, whether from Nature or from habit, this sense is so acute, that they can perceive the nicest distinctions in the favour of solids and of liquids.

The sensations conveyed to the mind by taste, like those of all the senses, are either agreeable, disagreeable, or indifferent. The pleasures arising from this sense are not only great, but highly useful to every animal. The sense itself, however, is comparatively gross; for, in smelling, hearing, and seeing, sensations are excited by emanations or undulations proceeding from bodies at great distances from the animals who perceive them. But, in tasting, the object must be brought into actual contact with the tongue before its qualities can be discovered. How this proportionally gross sense should have been selected, and figuratively applied to the general perception of every thing beautiful and sublime, whether in,

Nature or in art, it is difficult to determine. The inquiry, however, would not be incurious, whether men who have an obtuse sense of tasting material substances are likewise deficient in the perception of beauty and deformity.

Though the sense of taste varies in some individuals, yet, like figurative taste, the standard of agreeable and disagreeable, of pleasant and painful, is almost universally diffused over mankind and the brute creation. Every horse, and every ox, when in a natural state, eat and reject the same species of food. But men in society, as well as domestic animals, are induced by habit, by necessity, or by imitation, to acquire a taste for many dishes, and combinations of substances, which, before the natural discriminating sense is perverted, would be rejected with disgust.

Some individuals of the human species have an aversion to particular kinds of food, which are generally agreeable. This aversion may be either original or acquired. I knew a child, who, from the moment he was weaned, could never be induced to take milk of any kind. These original aversions must be ascribed to some peculiar modification in the structure of the organ, or in the disposition of its nerves. But, in general, disgust at particular foods is produced by surfeits, which injure the stomach, and create, in that exquisitely irritable viscus, an insuperable antipathy to receive nourishment which formerly gave it so much uneasiness to digest.

Brute animals, especially those which feed upon herbage, and are not liable to be corrupted by example or necessity, distinguish tastes with wonderful accuracy. By the application of the tongue, they instantly perceive whether any plant is salutary or noxious. To enable them, amidst a thousand plants, to make this discrimination, their nervous papillae, and their tongues, are proportionally much larger than those of man.

OF HEARING.

THE sensation of hearing is conveyed to the mind by undulations of air striking the ear, an organ of a very delicate and complex structure. In man and quadrupeds, the external ears are large, and provided with muscles by which they can erect and move them from side to side, in order to catch the undulations produced in the air by the vibrations of sonorous bodies, or to distinguish with greater accuracy the species of sound, and the nature and situation of the animal or object from which it proceeds. Though the human ears, like those of quadrupeds, are furnished with muscles, evidently intended for similar movements, yet, I know not for what reason, there is not one man in a million who has the power of moving his ears. When we listen to a feeble sound, we are conscious of an exertion ; but that exertion, and the motions produced by it, are confined to the internal parts of the organ.

The canals or passages to the internal parts of the ear are cylindrical, somewhat contorted, and become gradually smaller till they reach the *membrana tympani*, which covers what is called the drum of the ear. This membrane, which is extremely sensible, when acted upon by undulations of air, however excited, conveys, by means of a complex apparatus of bones, nerves, &c. the sensation of sound to the brain or sentient principle.

That air is the medium by which all sounds are propagated, has been established by repeated experiments. The sound of a bell, suspended in the receiver of an air-pump, gradually diminishes as the air is exhausted, till it almost entirely ceases to be heard. On the other hand, when the quantity of air is increased by a condenser, the intensity of the sound is proportionally augmented. Mr. Hauskbee, in a paper published in the Philosophical Transactions, has proved, that sounds actually produced cannot be transmitted

through a vacuum, or a space deprived of air. ‘I took,’ says he, ‘a strong receiver, armed with a brass hoop at the bottom, in which I included a bell as large as it could well contain. This receiver I screwed strongly down to a brass plate with a wet leather between, and it was full of common air, which could nowise make its escape. Thus secured, it was set on the pump, where it was covered with another large receiver. In this manner, the air contained between the outward and inward receivers was exhausted. Now here I was sure, when the clapper should be made to strike the bell, there would be actually sound produced in the inward receiver ; the air in which was of the same density as common air, could suffer no alteration by the vacuum on its outside, so strongly was it secured on all parts. Thus, all being ready for trial, the clapper was made to strike the bell ; but I found that there was no transmission of it through the vacuum, though I was sure there was actual sound produced in the inward receiver.’

To enable us to understand the manner in which sounds are propagated through the air, philosophers have had recourse to the undulations produced by a stone thrown into a pond of stagnating water. These undulations assume the form of circular waves, which successively proceed from the place where the stone struck the water, as from a center, and continually dilate, and become greater and greater as they recede from that center, till they reach the banks of the water, where they either vanish or are reflected. Now, as air is likewise a fluid, similar undulations, though to us invisible, are produced in it by the vibrations of sonorous bodies, and are also propagated to great distances in successive waves or rings. These undulations of the air, when they come into contact with our organs of hearing, make such a tremulous impression upon them as excites in our minds the sensation of sound. This analogy, though not altogether perfect, is

sufficient to illustrate those invisible motions of the air by which sounds are conveyed from one place to another, and to give an idea of echoes, or reflected undulations of that fluid.

The celerity with which sounds, or undulations of air, move, has been exactly computed. All sounds, whether acute or grave, strong or weak, move at the rate of 1142 feet in a second of time. Hence, whenever the lightning of thunder, or the fire of artillery, are seen, their actual distances from the observer may be easily ascertained by the vibrations of a pendulum. This velocity, it is true, may be a little augmented or diminished by favourable or by contrary winds, and by heat or cold. But the difference, even in high winds, is so trifling, that, for any useful purpose, it scarcely merits attention.

Infants hear bluntly, because the bones of their ears are soft and cartilaginous; and, of course, the tremulations excited in them by the motions of the air are comparatively weak. Young children, accordingly, are extremely fond of noise. It rouses their attention, and conveys to them the agreeable sensation of sound; but feeble sounds are not perceived, which give infants, like deaf persons, the appearance of inattention, or rather of stupidity.

The force or intensity of sound is augmented by reflection from surrounding bodies. It is from this cause that the human voice, or any other noise, is always weaker, and less distinctly heard, in the open air than in a house.

The modifications of sound are not less various than those of tastes or odours. The ear is capable of distinguishing some hundred tones in sound, and probably as many degrees of strength in the same tones. By combining these, many thousand simple sounds, which differ either in tone or in strength, are perceived and distinguished by the ear. A violin, a flute, a French-horn, may each of them give the

fame tone ; but the ear easily makes the distinction. The immense variety of sensations, arising from the organs of smelling, of tasting, and of hearing, enables animals to judge concerning the nature and situation of external objects. By habit we learn to know the bodies from which particular species of sounds proceed. Previous to all experience, we could not distinguish whether a sound came from the right or the left, from above or below, from a greater or a smaller distance, or whether it was the sound of a coach, of a drum, of a bell, or of an animal. By catching cold, I once had a temporary deafness in my left ear. I was surprised to find that I had lost the faculty of perceiving the situation from which sounds proceeded. If a dog barked on the left, I thought the noise came from the right. This circumstance excited my curiosity : But, upon recollection, I knew that my left ear was deaf ; and that every sound I heard was perceived solely by the right ; and, consequently, I discovered the cause of the deception.

Hearing enables us to perceive all the agreeable sensations conveyed to our minds by the melody and harmony of sounds. This, to man at least, is a great source of pleasure and of innocent amusement. But some men are almost totally destitute of the faculty of distinguishing musical sounds, and of perceiving those delightful and diversified feelings excited by the various combinations of musical tones. Most men derive pleasure from particular species of music. But a musical ear, in a restricted sense, is by no means a general qualification. An ear for music, however, though not to be acquired by study, when the faculty itself is wanting, may be highly improved by habit and culture. Buffon, after examining a number of persons who had no ear for music, says, that every one of them heard worse in one ear than in the other ; and ascribes their inability of distinguishing musical expression to that defect. But a musical ear seems to have

no dependence on acuteness or bluntness of hearing, whether in one ear or in both ears. There are many examples of people who may be said to be half deaf, and yet are both fond of music, and skilful practitioners. An ear for music, like a genius for painting, or poetry, is a gift of Nature, and is born with the possessor.

Beside the innumerable pleasures we derive from music and agreeable sounds, the extension and improvement of *artificial* language must be considered as objects of the greatest importance to the human race. Without the sense of hearing, mankind would forever have remained mute. I mention *artificial*, or improved language, because, from a thousand observations which every person must have made, it is perfectly apparent, that, if destitute of a *natural* language, neither man nor the brute creation* could possibly have existed and continued their species. As brutes, without information or experience, are capable of communicating to each other, by particular sounds and gestures, their pleasures and pains, their wants and desires, it would be the highest absurdity to suppose that the great Creator should have denied to man, the noblest animal that inhabits this globe, the same indispensable privilege. Without a basis there can be no fabric. Without a *natural* no *artificial* language could possibly have existed. This point is clearly demonstrated, in a few words, by that most ingenious, candid, and profound philosopher, Dr. Thomas Reid, Professor of Moral Philosophy in the University of Glasgow. ‘If mankind,’ says Dr. Reid, ‘had not a *natural* language, they could never have invented an *artificial* one by their reason and ingenuity. For all *artificial* language supposes some compact or agreement to affix a certain meaning to certain signs ; therefore, there must be compacts or agreements before the use of *artificial* signs ; but there can be no compact or

* Concerning the language of Beasts, I shall, perhaps, be more explicit in a future work.

‘agreement without signs, nor without language ; and therefore there must be a natural language before any artificial language can be invented*.’ Let any man try to overturn this argument, which is founded, not upon *metaphysical* conjecture, but upon the solid basis of *fact* and uncontrovertible *reasoning*. The elements, or constituent parts of the natural language of mankind, the Doctor reduces to three kinds ; modulations of the voice, gestures, and features. ‘By means of these,’ says he, ‘two savages, who have no common artificial language, can converse together ; can communicate their thoughts in some tolerable manner ; can ask and refuse, affirm and deny, threaten and supplicate ; can traffic, enter into covenants, and plight their faith.’

I can perceive only one plausible objection to this reasoning. If, it may be said, man were endowed with a natural language, this language must be universal ; from what source, then, can the great diversity of languages in different nations, and tribes of the human race be derived ? The solution of this question depends not upon metaphysical arguments, but upon fact and experience. I have had considerable opportunities of observing the behaviour of children. Infants, when very young, have nearly the same modes of expressing their pleasures and pains, their desires and aversions. These they communicate by voice, gesture, and feature ; and every infant, whatever be the country, climate, or language, uniformly expresses its feelings almost in the same manner. But, when they arrive at nine or twelve months of age, a different scene is exhibited. They then, beside the general expressions of feeling and desire, attempt to give names to particular objects. Here artifice begins. In these attempts, previous to the capacity of imitating articulate sounds, every individual infant utters different sounds, or rather gives differ-

* Dr. Reid’s Inquiry into the Human Mind, on the Principles of Common Sense, page 93.

ent names, to signify the same objects of its desire or aversion. Beside this natural attempt towards a nomenclature, infants, during the period above mentioned, (for the time varies according to the health and vivacity of the child), frequently make continued orations. These orations consist both of articulate and inarticulate sounds, of which no man can give an idea in writing. But most men, and every woman who has nursed children, will perfectly understand what I cannot express. From the fact, that children actually utter different sounds, or give different names to denote the same objects, I imagine, arises all that diversity of languages, which, by exhausting time and attention, retard the progress and improvement both of Art and Science. If any number of children, or of solitary savages, should chance to associate, the names of objects would soon be settled by imitation and consent. By observation and experience the number of names would be augmented, as well as the qualities or attributes of the objects themselves ; and, in the progress of time, a new and artificial language would be gradually formed. While this operation is going on in one corner of a country, twenty similar associations and compacts may be forming, or already formed, in different nations, or in different districts of the same nation, all of which would give birth to separate artificial languages.

OF TOUCH.

THE sensations of smelling, tasting, hearing, and seeing, are conveyed to us by partial organs, which are all confined to the head. But the sense of touching, or of feeling, is not only common to these organs, but extends over almost every part of the body, whether external or internal. Though every sensation may be comprehended under the general appellation of *feeling*, yet what is called the sense of *touch* is properly restricted to the different sensations excited by

bodies applied to the skin, and particularly to the tips of the fingers.

With regard to sensation in general, it is worthy of remark, that the eyes, the ears, the nostrils, the tongue and palate, the palms of the hands, especially towards the points of the fingers, are more amply supplied with nerves than any other external parts of the body. The terminations of the nerves on the surface of the skin are soft and pulpy, and form minute protuberances resembling the nap of freeze-cloth, though greatly inferior in magnitude. These protuberances have received the denomination of *nervous papillae*. They might be called *animal feelcrs*; for they are obviously the immediate instruments of sensation. If an object be presented to the eye, or any other organ of sensation, certain feelings are excited, which are either agreeable or disagreeable, according to the real or imaginary qualities which we consider as belonging to that object. The feelings thus excited instantly produce a change in the sensitive organs by which they are occasioned. If the object be possessed of disagreeable qualities, aversion is the necessary consequence. But, if beauty and utility are perceived in the object, pleasant emotions spring up in the mind, which naturally induce a similar tone or disposition in the organs suited for the enjoyment of these qualitics.

When examining or enjoying any object, it is natural to inquire, what are the changes produced in the nervous papillae, or organs of sensation? If an object possessed of agreeable feelings is perceived, the nervous papillae instantly extend themselves, and, from a state of flaccidity, become comparatively rigid like bristles. This extention of the papillae is not conjectural: It is founded on anatomical observation, and, in some cases, may be seen and felt by persons of acute and discerning sensations. When a man in the dark inclines to examine any substance, in order to discover its figure, or

other qualities, he perceives a kind of rigidity at the tips of his fingers. If the fingers are kept long in this state, the rigidity of the nervous papillae will give him a kind of pain or anxiety, which it is impossible to describe. The cause of this pain is an over-distension of the papillae. If a small insect creeps on a man's hand, when the papillae are flaccid, its movements are not perceived : But if he happens to direct his eye to the animal, he immediately extends his papillae, and feels distinctly all its motions. If a body be present, which, in the common state of the nerves, has scarcely any sensible odour, by extending the papillae of the nostrils, an agreeable, disagreeable, or indifferent smell will be perceived. When two persons are whispering, and we wish to know what is said, we stretch the papillae, and the other organs of hearing, which are exceedingly complex. If a sound is too low for making an impression on the papillae in their natural state of relaxation, we are apt to overstretch the organ, which produces a painful or irksome feeling. When we examine a mite, or any very minute object, by the naked eye, a pain is propagated over every part of that organ. Several causes may concur in producing this pain, such as the dilating of the pupil, and the adjusting the chryalline lens; but the chief cause must be ascribed to the preternatural intumescence and extension of the papillae of the retina, the substance of which is a mere congeries of nervous terminations. This circumstance confirms a former remark, that the immediate organs of sensation were more copiously supplied with nervous papillae than those parts whose uses require not such exquisite sensibility ; for a distinction in this respect is observable even among the sensitive organs themselves. They are furnished with nerves exactly proportioned to the subtlety of the objects whose impressions they are fitted to receive. The eye possesses by far the greatest number. The particles of light are so minute, that had not this wise provision been observed in the construction of the eye, it could never have

been able to distinguish objects with such accuracy as at present it is capable of performing. When an insipid body, or a body which conveys but a very feeble sensation of taste, is applied to the tongue, we are conscious of an effort which that organ makes in order to discover the quality of the body thus applied. This effort is nothing but the stretching of the nervous papillae, that they may enlarge the field of contact with the body under examination.

The pleasure or pain produced by the sense of touch depends chiefly on the friction, or number of impulses, made upon the papillae. Embrace any agreeable body with your hand, and allow it to remain perfectly at rest, and you will find the pleasure not half so exquisite as when the hand is gently moved backward and forward upon the surface. Apply the hand to a piece of velvet, and it is merely agreeable : Rub the hand repeatedly on the surface of the cloth, and the pleasant feeling will be augmented in proportion to the number of impulses on the papillae. When a man is pinched with hunger, the sight or idea of palatable food raises the whole papillae of his tongue and stomach. From this circumstance he is highly regaled by eating. But, if he eats the same species of food when the stomach is less keen, the pleasure in the one case is not to be compared with what is felt in the other. The cause is obvious : His desire was not so urgent ; the object, of course, was less alluring ; and therefore he was more remiss in erecting his papillae, or in putting them in a tone suited to such eminent gratification.

The same observations are applicable to disagreeable or painful objects of contact. If the hand is laid upon a gritty stone, or a piece of rusty iron, the feeling is disagreeable ; but if it is frequently rubbed upon the surface of these bodies, the feeling becomes insufferably irksome.

It is by the sense of touch that men, and other animals, are enabled to perceive and determine many qualities of ex-

ternal bodies. By this sense we acquire the ideas of hardness and softness, of roughness and smoothness, of heat and cold, of pressure and weight, of figure, and of distance. The sense of touch is more uniform, and liable to fewer deceptions, than those of smelling, tasting, hearing, and seeing; because, in examining the qualities of objects, the bodies themselves must be brought into actual contact with the organ, without the intervention of any medium, the variations of which might mislead the judgment.

OF SEEING.

OF all the senses, that of seeing is unquestionably the noblest, the most refined, and the most extensive. The ear informs us of the existence of objects at comparatively small distances; and its information is often imperfect and fallacious. But the organ of sight, which is most admirably constructed, not only enables us to perceive thousands of objects at one glance, together with their various figures, colours, and apparent positions, but, even when unarmed, to form ideas of the sun and planets, and of many of the fixed stars; and thus connects us with bodies so remote, that imagination is lost when it attempts to form a conception of their immense magnitude and distances. This natural field of vision, however, great, has been vastly extended by the invention of optical instruments. When aided by the telescope, the eye penetrates into regions of space, and perceives stars innumerable, which, without the assistance of art, would to us have no existence. Our ideas of the beauty, magnitude, and remoteness or vicinity of external objects, are chiefly derived from this delicate and acute instrument of sensation.

Before proceeding to the peculiarities of vision, and the general properties of light, we shall give a short description of the structure of the eye.

The globe of the eye is composed of three humours, called *aqueous*, *crystalline*, and *vitreous*; and of the *retina*, *ciliary ligament*, and *iris*. All these are contained within the *scleroteca* and *cornea*, or capsule of the eye. The white part of the cornea is opaque; but the *pupil*, or *sight* of the eye, through which the rays of light pass, is transparent. The *aqueous humour* is a *meniscus*, or a convex exteriorly, and concave internally. The *crystalline humour* is doubly convex; and its exterior convexity is embraced by the concave surface of the aqueous. The *vitreous humour* is likewise a meniscus; its concave surface embraces the interior convexity of the crystalline, and its convex surface is encompassed by the *retina*, which is a fine expansion of the medullary fibres of the optic nerve spread upon the convex surface of the vitreous humour, and covering the bottom of the eye. The *ciliary ligament* is a ring of fibres, which inclose the edges of the crystalline, and stretch in right lines towards its center. When these fibres contract, the distance between the retina and crystalline is lengthened; and that distance is shortened when these fibres are in a relaxed state. The *iris* is that coloured circle which surrounds the pupil.

By this curious apparatus all the phaenomena of vision are conveyed to the mind. But, before we enter upon the manner in which the different parts of the eye concur in transmitting the rays of light and the images of objects to the retina, it will be necessary to give some general ideas concerning the nature of light, which is the universal medium of vision.

Light consists of innumerable rays, which proceed in direct lines from every part of luminous bodies. The motion of light, though not instantaneous, is inconceivably swift. To give some comparative idea of its great velocity, it has been discovered by philosophers, that rays of light coming from the sun reach this earth in seven minutes. Now, the

distance of the earth from the sun is so immense, that, supposing a cannon ball to move at the rate of 500 feet in a second, it could not come from the sun to the earth in less than 25 years. At this rate, the velocity of light will be above 10 million of times greater than that of a cannon ball.

The rays of light, though they proceed in direct lines from luminous bodies, are refracted, or bent out of their course, in passing through different mediums, as the air, glass, and every transparent substance; but, when they fall upon opaque bodies, they are reflected. Rays proceeding from any object, and passing through a convex glass or lens, are refracted and collected into a point, or small space, at a certain distance from the glass, which is called the *focus* of that lens.

The white light conveyed to us by the sun is not homogeneous, but consists of seven differently coloured rays, or what are called the *primary colours*. These differently coloured rays were discovered by Sir Isaac Newton to have different degrees of refrangibility. When the white light of the sun was made to pass through a glass prism, he found, that, instead of retaining its original whiteness, it exhibited seven distinct colours, and that this phenomenon was produced by the several rays in the composition of white light being more or less refracted, or turned from their direct course. The simple primary colours are seven in number, namely, red, orange, yellow, green, blue, indigo, and violet. Red is the least, and violet the most refrangible parts of white light. A proper mixture of all the seven primary colours constitutes whiteness; and by various combinations of the primary colours, all the compound colours exhibited either in Nature or art are produced. Any surface appears black when it reflects little or no light.

The different humours of the eye, and the crystalline lens, are all denser than air or water; of course, their power of refracting the rays of light is likewise greater. The rays proceeding from every point of an object enter the pupil;

and the refraction of the different parts of the eye, which act as a lens, necessarily makes them cross each other in their passage to the retina. After crossing, they diverge till they are stopped by the retina, where they form an inverted picture. The upper part of the object is painted on the lower part of the retina, and the right side upon the left, &c. The celebrated Kepler first discovered, that distinct, but inverted pictures of every object we behold are painted on the retina by the rays of light proceeding from visible objects. This discovery naturally led Kepler, as well as many other philosophers since his time, to inquire how we should see objects erect from inverted images on the retina.

Many ingenious theories have been invented, and many volumes have been written, in order to explain this seemingly difficult question. To give even a cursory view of these theories would not only be tedious, but in a great measure useless. We shall therefore only remark, that their authors uniformly assumed it as a principle, that, because the pictures are inverted on the retina, the mind ought also to perceive them in the same position. It is certain, that, unless distinct images are painted on the retina, objects cannot be clearly perceived. If, from too little light, remoteness, or any other cause, a picture is indistinctly painted on the retina, an obscure or indistinct idea of the object is conveyed to the mind. The picture on the retina, therefore, is so far the cause of vision, that, unless this picture be clear and well defined, our ideas of the figure, colour, and other qualities of any object presented to the eye, will be obscure and imperfect. The retina of the eye resembles a canvas on which objects are painted. The colours of these pictures are bright or obscure, in proportion to the distances of the objects represented. When objects are very remote, their pictures on the retina, are so faint, that they are entirely obliterated by the vigorous and lively impressions of nearer objects, with

which we are every way surrounded. On the other hand, when near objects emit a feeble light only, compared with that which proceeds from a remote object, as, for example, when we view luminous bodies in the night, then very distant objects make distinct pictures on the retina, and become perfectly visible. Hence a man, by placing himself in a dark situation, and looking through a long tube, without the intervention of a glass, may make a kind of telescope, which will have a considerable effect even during the day. For the same reason, a man at the bottom of a deep pit can see the stars at noon.

The first and greatest error in vision, in the opinion of many authors, arises from the inverted representation of objects upon the retina; and they maintain, that, till children learn the real position of bodies by the sense of feeling, they see every object inverted. But new born animals, whether of the human or brute species, see objects, not inverted, but in their real positions, independently of all experience, or of any opportunity of rectifying the supposed illusion by the sense of touch. Animals see objects in their real position by a law of Nature, and by the instrumentality of the eye and optic nerve. Were it not a law of Nature, or of the constitution of animals, to see objects erect, though their images be inverted on the retinae, an inverted object could not possibly appear inverted; for, in this case, we should not be obliged to have recourse to experience, or to the sense of feeling. Besides, it is an established fact, that blind men, who had been restored to sight by chirurgical operations, instantly saw objects in their real position*. There is no relation to the principles of optics, in the sensation of feeling, by which an image, painted by rays of light on soft white nervous terminations, is conveyed through a most opaque body, in a long course of perfect darkness, to the brain. Indeed,

* Haller. Physiol. tom. 2, page 87.

the sense by which the perceiving nerves of any kind are affected, is not an image or idea of the object. The idea of redness has nothing in common with the least refrangible portions of light separated from the other six coloured rays of which white light is composed. The pain of burning represents not to the mind any thing of that swift and subtle matter by which the nervous threads are broken or destroyed. There is nothing in the idea of a sharp sound, from a cord of a certain length, which can inform the mind that this cord vibrates 2000 times in a second.*

Another question with regard to vision has been much agitated by philosophers. Because a separate image of every object is painted on the retina of each eye, it was concluded, that we naturally see all objects double; that we learn to correct this error of vision by the sense of touching; and that, if the sense of seeing were not constantly rectified by that of touching, we should be perpetually deceived as to the position, number, and situation of objects. The Count de Buffon mentions the real fact, though he ascribes it to a wrong cause. ‘When two images,’ says he, ‘fall on corresponding parts of the retina, or those parts which are always affected at the same time, objects appear single, because we are accustomed to judge of them in this manner. But, when the images of objects fall upon parts of the retinae which are not usually affected at the same time, they then appear double, because we have not acquired the habit of rectifying this unusual sensation. Mr. Cheffelden, in his anatomy, relates the case of a man who had been affected with a strabismus, or squinting, in consequence of a blow on the head. This man saw every object double for a long time: But he gradually learned to correct this error of vision, with regard to objects which were familiar to him; and, at last, he saw eve-

* For a more ample discussion of this point, see Haller. Physiol. tom. 2, &c and Dr. Reid's Inquiry.

'try object single as formerly, though the squinting was never removed. This is a proof still more direct, that we really see all objects double, and that it is by habit alone we learn to conceive them to be single*.'

In this, and other passages, the Count de Buffon has pointed out the genuine cause (or ultimate fact) why we see objects single with two eyes. He tells us, that, though a distinct image is painted on each retinae, whenever these images are painted on corresponding points of the retinae, an object is perceived to be single. It is equally true, that, when one eye is distorted by the finger, or any other cause, in such a manner that the images are painted on points of the retinae which do not correspond, the object is perceived to be double. Objects which are much nearer, or much more remote, than that to which both eyes are directed, appear double. If a candle is placed at the distance of ten feet, and a man holds his finger at arm's-length between his eyes and the candle, when he looks at the candle, he sees his finger double, and when he looks at his finger he sees the candle double. 'In this phaenomenon,' Dr. Reid properly remarks, 'it is evident to those who understand optics, that the pictures of objects which are seen double, do not fall upon points of the retinae which are similarly situated, but that the pictures of objects seen single do fall upon points similarly situated. Whence we infer, that as the points of the two retinae, which are similarly situated with regard to the centres, do correspond, so those which are dissimilarly situated do not correspond. It is to be observed, that although, in such cases as are mentioned in the last phaenomenon, we have been accustomed from infancy to see objects double which we know to be single ; yet custom, and experience of the unity of the object, never take away this appearance of duality†.'

* Buffon, vol. 3, pag. 7. Translat. † Dr. Reid's Inquiry, &c. page 287.

The sense of seeing, without the aid of experience, conveys no idea of distance. If not assisted by the sense of touching, all objects would seem to be in contact with the eye itself. Objects appear larger or smaller according as they approach or recede from the eye, or according to the angle they subtend. A fly, when very near the eye, seems to be larger than a horse or an ox at a distance. Children can have no idea of the relative magnitude of objects, because they have no notion of the different distances at which they are seen. It is only after measuring space by extending the hand, or by transporting their bodies from one place to another, that children acquire just ideas concerning the real distances and magnitudes of objects. Their ideas of magnitude result entirely from the angle formed by the extreme rays reflected from the superior and inferior parts of the object: Hence every near object must appear to be large, and every distant one small. But after, by touch, having acquired ideas of distances, the judgment concerning magnitude begins to be rectified. If we judge solely by the eye, and have not acquired the habit of considering the same objects to be equally large, though seen at different distances, the nearest of two men, though of equal size, would seem to be many times larger than the farthest. But we know that the last man is equally large with the first; and, therefore, we judge him to be of the same dimensions. Any distance ceases to be familiar to us, when the interval is vertical, instead of being horizontal; because all the experiments by which we usually rectify the errors of vision, with regard to distances, are made horizontally. We have not the habit of judging concerning the magnitude of objects which are much elevated above or sunk below us. This is the reason that, when viewing men from the top of a tower, or when looking up to a globe or a cock on the top of a steeple, we think these objects much smaller than when seen at equal distances in a

horizontal direction. During the night, on account of the darkness, we have no proper idea of distance, and, of course, judge of the magnitude of objects solely by the largeness of the angle or image formed in the eye, which necessarily produces a variety of deceptions. When travelling in the night, we are liable to mistake a bush that is near us for a tree at a distance, or a distant tree for a bush which is at hand. When benighted in a part of the country with which we are unacquainted, and, of course, unable to judge of the distance and figure of objects, we are every moment liable to all the deceptions of vision. This is the origin of that dread which some men feel in the dark, and of those ghosts and horrible figures which so many people positively assert they have seen in the night. Such figures are commonly said to exist in the imagination only ; but they often have a real existence in the eye ; for, when we have no other mode of recognising unknown objects but by the angle they form in the eye, their magnitude is uniformly augmented in proportion to their vicinity. If an object, at the distance of twenty or thirty paces, appears to be only a few feet high, its height, when viewed within two or three feet of the eye, will seem to be many fathoms. Objects, in this situation, must excite terror, and astonishment in the spectator, till he approaches and recognises them by actual feeling ; for the moment a man examines an object properly, the gigantic figure it assumed in the eye instantly vanishes, and its apparent magnitude is reduced to its real dimensions. But if, instead of approaching an object of this kind, the spectator flies from it, he retains the idea which the image of it formed in his eye, and he may affirm with truth, that he beheld an object terrible in its aspect, and enormous in its size. Hence the notion of spectres, and of horrible figures, is founded in nature, and depends not solely on imagination.

When we have no idea of the distance of objects by a previous knowledge of the space between them and the eye, we try to judge of their magnitudes by recognising their figures. But, when their figures are not distinguishable, we perceive those which are most brilliant in colour to be nearest, and those that are most obscure to be at the greatest distance. From this mode of judging many deceptions originate. When a number of objects are placed in a right line, as lamps in a long street, we cannot judge of their proximity or remoteness but by the different quantities of light they transmit to the eye. Of course, if the lamps nearest the eye happen to be more obscure than those which are more remote, the first will appear to be last, and the last first.

Before I dismiss this subject, I feel an irresistible desire of giving a short view of the Abbe de Condillac's *Traite des Sensations**; a most ingenious performance, which, I believe, is not very generally known in this country.

In an advertisement prefixed to this Treatise, the sagacious and learned Abbe desires his readers to abstract themselves from all their preconceived opinions, and to imagine the situation and feelings of a statue, limited, at first, to a single sense, and afterwards acquiring gradually the whole five.

1. Sense of smelling alone.

A man, or a statue, who had no sense but that of smelling, could have no other ideas than those of odours. He would be the smell of a rose, a violet, or a jessamine, according as the effluvia of these objects acted upon his single organ of sensation. From agreeable or disagreeable smells he would acquire ideas of pleasure and pain. By means of agreeable and disagreeable smells frequently repeated, these

* From the edition 1754, in two volumes 12m.

sensations would remain in his memory, and produce desire and aversion. He can now compare the smell of a rose with that of an hemlock. As soon as he compares, he judges of the relation between two ideas. In proportion as these comparisons or judgments are repeated, he acquires, by habit, a greater facility in making them. He can judge of different degrees of pleasure and pain. Hence, when he feels uneasy, he recals pleasant sensations which are past, and wishes for their return. This is the origin of desire and want. Memory is the recollection only of what is past ; but, when the ideas of objects present themselves in so lively a manner, that he believes they are actually present, this operation of the mind is called imagination. Being limited to the use of one sense, he would learn to distinguish smells with greater accuracy than beings endowed with more sources of information. Abstraction is the separation of two ideas which have a natural connection. By reflecting that the ideas of pain and pleasure result from different modifications of his existence, he contracts the habit of separating them, and thus acquires abstract notions. To our statue, a violet is a particular idea only ; consequently, all his abstractions are limited to different degrees of pleasure and pain. The succession of sensations will give him some faint ideas of number, of past, and of future time. Duration is an idea purely relative, and changes according to the rapidity or slowness of our perceptions. Our statue is incapable of distinguishing dreams, or a lively imagination, from real sensations. By the aid of memory he recognises his identity, and knows his present from his past condition. From these remarks it appears, that a man limited to one sense is capable of acquiring the rudiments of every human faculty, and that these faculties are only extended by the addition of other senses. Nearly the same acquisitions would be made, if a man were limited to any of the other senses.

2. Of Hearing alone.

The pleasures of the ear arise chiefly from the succession of sounds conformably to the rules of melody or of harmony. Hence our statue's desires would not be confined to a single sound ; he would wish to become a complete air. Sounds produce greater emotions than odours. They excite joy or sadness independently of acquired ideas. Noise alone, without musical expression, would be agreeable : And music would convey pleasure proportioned to the exercise of the ear. Simple, and even coarse songs, would at first be ravishing. But, when gradually accustomed to music more compounded, the ear would discover new sources of delight. The pleasure of a succession of musical tones being superior to that of a continued noise, he would not confound the one with the other.

3. Smelling and Hearing united.

As these senses, taken separately, give to our statue no idea of external objects, neither can they by their union. He would never suspect that he had two different organs of perception, nor, at first, distinguish two modes of existence in himself. Sounds and odours would be confounded, and seem to be only one simple modification. He would learn, however, by experience, and the aid of memory, to distinguish two sensations ; and then he would think that his existence was double. His train of ideas is more varied and extensive, because he has two kinds of modification ; and, perhaps, noise would seem so different from harmonious sounds, that he might imagine he had three senses.

4. Taste alone, and Taste united with Smelling and Hearing.

When limited to taste alone, the statue would acquire the same mental powers as with smelling or hearing. Taste

would contribute more to his happiness and misery than smelling or hearing ; because favours, in general, affect us more than finells, or even harmonious sounds.

When taste is united with finelling and hearing, the statue, after learning to know them separately, would be enabled to distinguish these sensations, even when transmitted to him at the same time ; and therefore his existence would in some measure be tripled. The union of these senses would still farther extend and diversify the train of his ideas, augment the number of his desires, and make him contract new habits.

5. *Of Sight alone.*

Sight and all sensations are internal, and belong to the mind. The difficulty is to conceive how we refer these sensations to external objects or causes. Our statue would consider light and colour as modes of his own existence ; but could have no idea that they belonged to bodies distinct from himself. At first he would not be able to distinguish one colour from another ; but he would soon acquire the habit of considering one colour at a time, and thus learn to distinguish them. By sight alone he could have no idea of figure, situation, extension, or motion.

6. *Sight united with Smell, Hearing, and Taste.*

This union would augment our statue's mode of existence, extend the chain of his ideas, and multiply the objects of his attention, of his desires, and of his enjoyments. But he would still continue to perceive himself alone, and could have no idea of external objects. He would see, smell, taste, and hear, without knowing that he had eyes, nose, mouth, or ears, nor even that he had a body. With the same colour before his eyes, if a succession of smells, favours, and sounds, were presented to him, he would consider himself as a colour

successively odorous, savoury, and sonorous. If the same odour were constantly present with him, he would consider himself as a savoury, sonorous, and coloured odour.

7. *Of Touching alone.*

The smallest degree of sentiment, or feeling, which a man limited to the sense of touching could have, would arise from the action of different parts of the body, and particularly from the motion of respiration. This the Abbe calls the *fundamental sentiment*, because with it life commences. As soon as this fundamental sentiment has undergone any change, the statue is conscious of his own existence. When not struck by any external body, and placed in a temperate tranquil air, of an equal degree of heat, he would only recognise his existence by the confused impression resulting from the motion of respiration. He cannot distinguish the different parts of his body, and consequently has no idea of extension. Different feelings perceived at the same time convey a confused sensation only. But, when heat and cold are felt in succession, he distinguishes them, and retains in his memory the idea of each sensation. Touching different parts of his body, and of external objects, gradually unfolds the ideas of extension, solidity, softness, hardness, distance, &c. Hence he no longer confounds himself with his modifications. He is no longer heat or cold; but he perceives heat in one part and cold in another. By means of the hand, he distinguishes his own person from external objects. When he touches the parts of his body, each part returns a sensation. But, when he touches another body, he feels that it exists, but returns no sensation; and hence he learns that there are bodies which constitute no part of himself.

Children derive the greatest happiness from motion. Even falls do not deter them. A bandage on their eyes would give them less pain than a restraint on the use of their

limbs. Motion, beside many other advantages, gives them the most lively consciousness of their own existence and powers. If exercise be pleasant to children, it would be still more so to our statue ; for as yet he not only knows no obstacle to interrupt his movements, but he will soon experience all the pleasures to be derived from motion. The statue at first loves every body that does not hurt him. Polished and smooth surfaces will be agreeable to him ; and he will be delighted to find that he can at pleasure enjoy warmth or coolness. He will receive peculiar pleasure from objects, which, from their figure and magnitude, are most accommodated to the form of his hand. At other times, the difficulty of handling objects, on account of their size or weight, will give him pleasure by surprise ; and this pleasure will be augmented by the space he discovers around them, which will render the motion of his body from one place to another extremely agreeable. Solidity and fluidity, hardness and softness, motion and rest, will be pleasant sensations ; for the more he contrasts them, the more they will attract his attention and extend his ideas. But the habit he acquires of comparing and judging is the greatest source of his pleasures. He no longer touches objects solely for the pleasure of handling them. He wishes to know their relations, and he feels as many agreeable sensations as he forms new ideas.

Touching exposes him more frequently to pain than the other senses. But pleasure is always within his reach, and pain is felt only at intervals. His desires consist chiefly of the efforts of his mind to recall the most agreeable ideas. But that kind of desire of which the sense of touch renders him capable, includes motion, or the power of searching for sensations. Hence his enjoyments are not limited to the ideas presented by the imagination, but extend to all the objects he can reach ; and his desires, instead of being concentrated into modes of his existence, as in the other senses,

lead him always to external bodies, which are the objects of his love, hatred, and other passions.

By motion he acquires the idea of space. Repeated experience of discovering new sensations renders him capable of curiosity. But pain represses his desire of moving, and makes him diffident. Hence he learns to move with caution; and the same chance that led him to lay hold of a stick, will teach him to use it for exploring what may be hurtful to him. Pleasure and pain are the sources of all his ideas, the number of which acquirable by our statue is almost infinite. He learns to compare his different sensations, and to distinguish different bodies. He acquires the idea of figure, and becomes capable of reflection and abstraction. He acquires likewise the ideas of number, of duration, of space, and of immensity.

8. Of Touch united with Smelling.

On this supposition, the statue would perceive himself to be two different beings, one that he could touch, and another which he could not. When chance made him lay hold of an odorous body, he would find that its smell was stronger or weaker, in proportion as he brought the body nearer, or removed it farther from his face. This experiment frequently repeated will give him the idea that smell proceeds from, or is a quality of bodies. By the same means he discovers the organ of smelling. From this source his ideas concerning the qualities of bodies are greatly extended.

9. Hearing, Taste, and Touching, united.

At first our statue is totally occupied with this new sense, and believes himself to be the singing of birds, the noise of a cascade, &c. By the exercise, however, of handling sonorous bodies, or of letting them fall, he perceives that sound is produced by impulse or collision, gradually discovers this new organ, and that noise is a property of bodies even at a distance.

10. Of Sight uniu'ed with all the other Senses.

The eye conveys no idea of distance, of magnitude, of figure, or of situation, without the assistance of touching. Either from chance, or from the pain occasioned by too strong a light, the statue carries his hand to his eyes. The colours of objects instantly disappear. He removes his hand, and the colours return. Hence he learns that colours are not modes of his existence, but that they seem to be something existing in his eyes, in the same manner as he feels at the ends of his fingers the objects he touches.

The Abbe, in the same ingenious manner, shews how, by experience and habit, by motion and touching, we acquire a facility in correcting the errors of vision. But our limits permit us not to follow him an farther.

CHAPTER VII.

Of Infancy.

BY the term *Infancy*, in this chapter, is generally meant that portion of life which commences at birth, and terminates at that period when animals have acquired the power of self-preservation, without any assistance from their parents. This period varies greatly in different animals. Of course, when different species are mentioned, the term *infancy* must have very different limitations with regard to time.

The state of infancy, in the human species, continues longer than in any other animal. Infants, immediately after birth, are indeed extremely helpless, and require every assistance and attention from the mother. Most writers, however, on this subject seem to have exaggerated not only the imbecility, but the miseries of the infant state. ‘An infant,’ says Buffon, ‘is *more helpless* than the young of any other animal : ‘ Its uncertain life seems every moment to vibrate on the borders of death. It can neither move nor support its body : It has hardly force enough to exist, and to announce, ‘ by groans, the pain which it suffers ; as if Nature intended ‘ to apprise the little innocent, that it is born to misery, and ‘ that it is to be ranked among human creatures only to partake of their infirmities and of their afflictions*.’

This humiliating picture is partly just, and partly misrepresented. Though infants remain longer in a state of imbecility than the young of other animals, they are by no means more helpless. The instant after birth, they are capable of sucking whatever is presented to their mouths. When in the same condition, the young of the opossum, of hares, rabbits, rats, mice, &c. can do more. They can

* Buffon, vol. 2, page 369. Translat.

neither move nor support their bodies. Besides, many quadrupeds are destitute of the sense of seeing for several days after birth. But the faculty of vision is enjoyed by infants the moment after they come into the world. This faculty, in a few hours, becomes a great source of pleasure and amusement to them ; but it is denied, for some days, to many other species of animals. The young of most birds are equally weak and helpless as human infants. The former have no other powers but those of respiration, opening their mouths to receive food from the parent, and ejecting the excrement, after the food has been properly digested. If infants really suffer more pain and misery than other animals in the same state, Nature seems not to merit that severity of censure which she has sometimes received. Man in society, like domestic animals, by luxury, by artificial modes of living, by unnatural and vicious habits, debilitate their bodies, and transmit to their progeny the seeds of weakness and disease, the effects of which are not felt by those who live more agreeably to the general oeconomy and intentions of nature. The children of savages, for the same reason, whether in the hunting or shepherd state, are more robust, more healthy, and liable to fewer diseases than those produced by men in the more enlightened and refined stages of society. Even under the same governments, and in the same state of civilization, a similar gradation of imbecility and disease is to be observed. The children of men of rank and fortune are, in general, more puny, debilitated, and diseased, than those of the peasant or artificer. Still, however, children, in their progress from birth to maturity, have innumerable sources of pleasure, which alleviate, if they do not fully compensate, the pain which must unavoidably be endured, whether in a more natural or more artificial state of mankind. If luxury and civilization debilitate the constitutions of children, they give rise to many real enjoyments which are totally unknown to the

savage. His wants are fewer ; but his gratifications are more than proportionally diminished.

Though the period of human infancy be proportionally long, it is too often increased by improper management. In this, and many other countries of Europe, infants have no sooner escaped from the womb of their mothers, and have enjoyed the liberty of stretching their limbs, than they are again condemned to a more cruel and unnatural bondage. The head is fixed in one position ; the legs are fettered ; the arms are bound down to the sides ; and the little innocents are laced with bandages so strait that they cannot move a single joint. The restraint of swaddling bands must be productive of pain. Their original intention was to prevent the head and limbs from being distorted by unnatural or hurtful positions. But it was not considered, that the efforts made by infants to disentangle themselves, have a greater tendency to distort their members than any postures they could assume, if they enjoyed a greater degree of liberty. But, if the efforts for liberty made by infants fettered in this cruel manner be hurtful, the state of inactivity in which they are forced to remain, is, perhaps, equally noxious. Infants, as well as all young animals, are extremely prone to motion. It promotes the growth and expansion of their organs. It likewise invigorates all their members, and facilitates the circulation and secretion of their different fluids. But, when infants are deprived of exercise, or of the power of performing their natural movements, the opposite effects are produced. The want of exercise retards their growth and weakens their constitution. Those children, therefore, who are allowed full freedom of motion will always be the most healthy and the most vigorous. We are, however, happy to remark, that, by the efforts of philosophers and physicians, the practice of employing tight bandages has of late become less general, especially among intelligent midwives and mothers. But, to

eradicate long established prejudices, and to diffuse more enlightened and salutary notions through a whole country, cannot be effected without a great length of time and vigorous exertions.

From what causes or circumstances particular modes in the management of infants originate, it is difficult to determine. But it is certain that savages, and ruder nations, in their treatment of infants, often discover more discernment, and propriety of conduct, than are to be found in the most polished stages of society. The negroes, the savages of Canada, of Virginia, of Brasil, and the natives of almost the whole of South America, instead of using swaddling-bands, lay their infants naked into hammocks, or hanging beds of cotton, or into cradles lined with fur. The Peruvians leave the arms of their infants perfectly loose in a kind of swathing-bag. When a little older, they are put, up to the middle, in a hole dug out of the earth, and lined with linen or cotton. By this contrivance, their arms and head are perfectly free, and they can bend their bodies, and move their arms and head, without the smallest danger of falling, or of receiving any injury. To entice them to walk, whenever they are able to step, the breast is presented to them at a little distance. The children of negroes, when very young, cling round, with their knees and legs, one of their mother's haunches, and grasp the breast with their hands. In this position they adhere so firmly, that they support themselves without any assistance, and continue to suck without danger of falling, though the mother moves forward, or works at her usual labour. These children, at the end of the second month, begin to creep on their hands and knees ; and, in this situation, they acquire, by habit, the faculty of running with surprising quickness.

Savages are remarkably attentive to the cleanliness of their children. Though they cannot afford to change their furs

so frequently as we do our linen, this defect they supply by other substances of no value. The savages of North America put wood-dust, obtained from decayed trees, into the bottom of the cradle, and renew it as often as it is necessary. Upon this powder the children are laid, and covered with skins. This powder is very soft, and quickly absorbs moisture of every kind. The children in Virginia are placed naked upon a board covered with cotton, and furnished with a proper hole for transmitting the excrement. This practice is likewise almost general in the eastern parts of Europe, and particularly in Turkey. It has another advantage : It prevents the dismal effects which too often proceed from the negligence of nurses.

Many northern nations plunge their infants, immediately after birth, into cold water, without receiving any injury. The Laplanders expose their new-born infants on the snow till they are almost dead with cold, and then throw them into a warm bath. During the first year, this seemingly harsh treatment is repeated three times every day. After that period, the children are bathed in cold water thrice every week. It is a general opinion in northern regions, that cold bathing renders men more healthy and robust ; and hence they inure their children, from their very birth, to this habit. In the isthmus of America, the inhabitants, even when covered with sweat, plunge themselves with impunity into cold water. The mothers bathe in cold water, along with their infants, the moment after delivery ; yet much fewer of them die of child-bearing, than in nations where a practice of this kind would be considered as extremely hazardous.

With regard to the food of infants, it should consist, for the first two months, of the mother's milk alone. A child may be injured by allowing it any other nourishment before the end of the first month. In Holland, in Italy, in Turkey, and over the whole Levant, children, during the first

year, are not permitted to taste any other food. The Canadian savages nurse their children four or five years, and sometimes six or seven. In cases of necessity, the milk of quadrupeds may supply that of the mother. But, in such cases, the child should be obliged to suck the animal's teat ; for the degree of heat is always uniform and proper, and the milk, by the action of the muscles, is mixed with the saliva, which is a great promoter of digestion. Several robust peasants have been known to have had no other nurses than ewes. After two or three months, children may be gradually accustomed to food somewhat more solid than milk. Before the teeth shoot through the gums, infants are incapable of mastication. During that period, therefore, it is obvious that Nature intended they should be nourished solely by soft substances. But, after they are furnished with teeth, it is equally obvious, that they should occasionally be allowed food of a more solid texture.

The bodies of infants, though extremely delicate, are less affected by cold than at any other period of life. This effect may be produced by the superior quickness in the pulsation of the heart and arteries which takes place in small animals. The pulse of an infant is more frequent than that of an adult. The pulse of a horse, or of an ox, is much slower than that of a man ; and the motion of the heart, in very small animals, as that of a linnet, is so rapid that it is impossible to count the strokes.

The lives of children, during the first three or four years, are extremely precarious. After that period, their existence becomes gradually more certain. According to Simpson's tables of the degrees of mortality at different ages, it appears, that, of a certain number of infants brought forth at the same time, more than a fourth part of them died in the first year, more than a third in two years, and at least one half at the end of the third year. Mr. Simpson made this

experiment upon children born in London. But the mortality of children is not nearly so great in every place; for M. Dupre de S. Maur, by a number of experiments made in France, has shown, that one half of the children born at the same time are not extinct in less than seven or eight years.

To treat of the diseases of children, or to enter minutely into the causes which contribute to the great mortality of mankind in earlier infancy, is no part of our plan. In general, these causes are to be referred to unnatural practices in the management of children, introduced by superstition, by ignorance, and by foolish notions arising from over-refinement, from prejudice, and from hypothetical systems, while the oeconomy and analogy of Nature, in the conduct and situation of the inferior animals, are almost totally neglected. Every animal, except the human species, brings forth its young without any foreign aid. But incredible numbers of children, as well as of mothers, are daily maimed, enfeebled, and destroyed, by the ignorance and barbarity of midwives and accoucheurs. An infant is no sooner brought into the world than it is crammed with physic. Nature's medicine for cleansing the bowels of infants is the milk of the mother. But midwives absurdly imagine that drugs will answer this purpose much better. All other animals that give suck nurse their own offspring: But we too frequently delegate this tender and endearing office to strange women, whose constitutions, habits of life, and mental dispositions, are often totally different from those of the genuine parent. Infants, recently after birth, frequently suffer from giving them, instead of the mother's milk, wine-whey, water-gruel, and similar unnatural kinds of nourishment. In this period of their existence, however, very little food, but a great deal of rest, is necessary for promoting their health, and securing their ease and tranquility; for infants, when not teased by officious cares, sleep almost continually during several weeks

after birth. Young animals are naturally fond of being in the open air ; but our infants, particularly in large towns, are almost perpetually shut up in warm apartments, which both relaxes their bodies and enervates their minds. The great agility, strength, and fine proportions of savages, are results of a hardy education, of living much in the open air, and of an unrestrained use of all their organs the moment after they come into the world.

In young animals, as well as in infants, there is a gradual progress, both in bodily and mental powers, from birth to maturity. These powers are unfolded sooner or later, according to the nature and exigencies of particular species. This progress, in man, is very slow. Man acquires not his full stature and strength of body till several years after the age of puberty : And, with regard to his mind, his judgment and other faculties cannot be said to be perfectly ripe before his thirtieth year.

In early infancy, though the impressions received from new objects must be strong, the memory appears to be weak. Many causes may concur in producing this effect. In this period of our existence, almost every object is new, and, of course, engrosses the whole attention. Hence the idea of any particular object is obliterated by the quick succession and novelty of others, joined to the force with which they act upon the mind. Haller ascribes this want of recollection to a weakness of memory ; but it seems rather to proceed from a confusion which necessarily results from the number and strong impressions of new objects. The memory ripens not so much by a gradual increase in the strength of that faculty, as by a diminution in the number and novelty of the objects which solicit attention. In a few years children are enabled to express all their wants and desires. The number of new objects daily diminishes, and the impressions made by those with which they are familiar become comparatively

small and uninteresting. Hence their habits of attention, and the ardour of their minds, begin to relax. Instead of a general and undistinguishing gratification of their senses, this is the period when it is necessary to stimulate children, by various artifices, to apply their minds steadily to the examination of particular objects, and to the acquisition of new ideas from more complicated and refined sources of information. The great basis of education is a habit of attention. When this important point is gained, the minds of children may be molded into any form. But that restlessness, and appetite for motion, which Nature, for the wisest purposes, has implanted in the constitution of all young animals, should not be too severely checked. Health and vigour of body are the surest foundations of strength and improvement of mind.

With regard to the duration of infancy, from man to the insect tribes, it seems, in general, to be proportioned, not to the extent of life, but to the sagacity or mental powers of the different classes of animated beings. The elephant requires 30 years, and the rhinoceros 20, before they come to perfect maturity, and are enabled to multiply their species. But these years mark not the period of infancy; for the animals, in a much shorter time, are capable of procuring their own food, and are totally independent of any aid from their parents. The same remark is applicable to the camel, the horse, the larger apes, &c. Their ages of puberty are four, two and a half, and three years. But, in these quadrupeds, the terminations of infancy are much more early. The smaller quadrupeds, as hares, rats, mice, &c. are mature at the end of the first year after birth; and the Guiney pig and rabbit require only five or six months. There is a gradation of mental powers, though not without exceptions, from the larger to the more minute quadrupeds; for the dog and fox, whose sagacity is very great, come to maturity

in one year, and their state of infancy is short. But, of all animals, the infancy and helpless condition of men are the most prolonged ; and the superiority and ductility of his mind will not be questioned.

The infant state of birds is very short. Most of the feathered tribes arrive at perfection in less than six months ; and their sagacity is comparatively limited.

With regard to fishes, if the whale and seal kind, who suckle their young, be excepted, they receive no aid from their parents. Fishes no sooner escape from the eggs of their mother, than they are in a condition to procure nourishment, and to provide, in some measure, for their own safety. Of the sagacity of fishes, owing to the element in which they live, we have very little knowledge. But their general character is stupidity, joined to a voracious and indiscriminating appetite for food. In opposition to an almost general law of Nature which subsists among other animals, fishes devour, without distinction, every smaller or weaker animal, whether it belongs to a different species, or to their own. In animals of a much higher order, voracity of appetite is seldom accompanied with ingenuity or elegance of taste. When the principal attention of an animal is engrossed with any sensual appetite, it is a fair conclusion that the mental powers are weak, because they are chiefly employed upon the grossest of all objects. If this observation be just, fishes must be ranked among the most stupid animals of equal magnitude and activity.

The infant state of insects is a various and complicated subject. After they escape from the egg, they undergo so many changes, and assume such a variety of forms, that it is difficult to determine the period of their existence which corresponds to the condition of infancy in the larger animals. Different species remain longer or shorter in the form of worms, caterpillars, or grubs, before they are changed

into chrysalids, and afterwards into flies. When young, like other animals, they are small and feeble : But, even in their most helpless condition, with a very few exceptions, Nature is their only nurse. They require no aid from their parents, who, in general, are totally unacquainted with their progeny. But, as formerly observed, when treating of instinct, the mothers uniformly deposit their eggs in situations which afford both protection and nourishment to their young. The parent fly, according to the species, invariably, unless restrained by necessity, deposits her eggs upon particular plants, in the bodies of other animals, in the earth, or in water. Whenever, therefore, an insect receives existence in its primary form, all its wants are supplied. Though the mother, after the worms issue from the eggs, takes no charge of her offspring, and frequently does not exist at the time they come forth, yet, by an unerring and pure instinct, she uniformly places them in situations where the young find proper nourishment, and every thing necessary to their feeble condition.

To this general law, by which insects are governed, there are several exceptions. Bees, and some other flies, not only construct nests for their young, but actually feed, and most anxiously protect them.

From what has been said concerning the infancy of animals, one general remark merits attention. Nature has uniformly, though by various modes, provided for the nourishment and preservation of all animated beings while they are in an infantine state. Though the human species continues long in that state, the attachment and solicitude of both parents, instead of abating, in proportion to the time and labour bestowed on their progeny, constantly augment, and commonly remain during life. The reciprocal affection of parents and children is one of the greatest sources of human happiness. If the love of children were not strong, and if it did not increase with time the labour, the constant

attention, the anxiety and fatigue of mothers would be insufferable. But here Nature, whose wisdom is always conspicuous, makes affection brave every difficulty, and sooth every pain. If a child be sickly, and require uncommon care, the exertions of the mother are wonderfully supported: Pity unites with love; and these two passions become so strong, that hardships, and fatigue of every kind, are suffered with cheerfulness and alacrity.

With regard to the inferior tribes of animals, Nature has not been less provident. To quadrupeds and birds she has given a strong and marked affection for their offspring, as long as parental care is necessary. But, whenever the young begin to be in a condition to protect and provide for themselves, the attachment of the parents gradually subsides; they become regardless of their offspring, at last banish them with blows, from their presence, and, after that period, seem to have no knowledge of the objects which so lately engrossed all the attention of their minds, and occupied all the industry and labour of their bodies.—Here the dignity and superiority of man appears in a conspicuous light. Instead of losing the knowledge of his offspring after they arrive at maturity, his affection expands, and embraces grandchildren, and great-grandchildren, with equal warmth as if they had immediately originated from himself.

CHAPTER VIII.

Of the Growth, and Food, of Animals.

IT is a law of Nature, that all organized bodies, whether animal or vegetable, require food, in order to expand and strengthen their parts when young, and to preserve health and vigour after they have arrived at maturity. The food of animals is digested in the stomach and intestines: By this process it is converted into chyle, and absorbed by the lacteal vessels, in the manner described in Chap. 2. page 48. But how this chyle, or nutritious matter, after mingling with the general mass of blood, contributes to the growth, and repairs the waste of animal bodies, is a mystery which probably never will be unfolded by human sagacity. It has, however, like many other secrets of Nature, given rise to several ingenious theories and conjectures, some of which shall be slightly mentioned.

Buffon considers the bodies of animals and vegetables as what he calls *internal moulds*. He says, that the matter of nutrition is not applied by *juxta-position*, but that it penetrates the whole mass; that each part receives and applies those particles only which are peculiar and necessary to its own nature; and that, by this means, the whole parts of the body are gradually and proportionally augmented. This nutritive matter, he remarks, is organic, and similar to the body itself; and hence the size of the body is increased, without any change in its figure or substance. The matter ejected by the different excretions he considers to be a separation of the dead from the vivifying and organic parts of nourishment, which are distributed over the body by an active power: This power similar to that of gravity, penetrates the internal substance of the body, and attracts the organic particles, which are thus pushed on through all its

parts. As these organic particles are similar to the body itself, their union with the different parts augments its size, without changing its figure. To unfold an embryo or germ, nothing more is requisite than that it contain, in miniature, a body similar to the species, and be placed in proper circumstances for the acquisition of fresh organic particles to increase its size and unfold its members. Hence nutrition, developement, and reproduction, are all effects of the same cause.

This account of the nutrition and growth of organic bodies has the appearance of an ingenious theory. But an attentive reader will easily perceive, that it contains no other information, than that animals and vegetables are nourished and grow by the intervention of the nutritious particles of food. This is a fact universally known and admitted. But we are still as ignorant as ever of the mode by which this mysterious operation is performed.

Other authors have supposed that the brain is a large gland ; that the nerves distributed over the whole body are the ducts or canals of this gland ; and that the principal use of the brain is to secrete nutritious matter, and to transmit it by the nerves to the various parts of the system, in order to expand the different organs of which it is composed, or to repair the waste they may have suffered from labour and other causes.

This theory presupposes that the nerves are tubular, and contain a fluid : But both of these circumstances have hitherto eluded the research of the ablest anatomists. Besides, the learned and indefatigable Doctor Monro, in his *Nervous System*, has rendered it highly improbable that the nerves are the instruments of nutrition. The Doctor reasons in the following manner. On comparing different animals, he remarks, we find no correspondence between the size of their brain, the rapidity of their growth, or the quantity of nourish-

ment they receive. An ox is six times heavier than a man ; but the brain of an ox weighs not above a fourth part of that of a man. On this supposition, an ox's brain must secrete twenty-four times more nourishment than a portion equal to it of the human brain. In two years an ox acquires his full size. His brain must, of course, be supposed to transmit daily through the nerves two or three pounds of flesh, bones, &c. But the much larger brain of a man does not, in an equal time, add to his body a fiftieth part of that weight.

‘ In monsters, says the Doctor, ‘ I have found the limbs ‘ very plump, though the brain was very small. Nay, in ‘ some monsters, the head has been wanting, yet the limbs ‘ were as large and perfect as common. In other monsters ‘ with one head and two bodies, I have found that the brain ‘ furnished the nerves of the head and spinal marrow on the ‘ right side of the monster ; yet the left spinal marrow, at the ‘ top of which there was only a small medullary knob, about ‘ the size of a large pea, was as perfect as the right one ; and ‘ that body, and its limbs, were as large, and as well nourish- ‘ ed, as those on the right side. On the other hand, where ‘ there were two heads of the ordinary size, and only one ‘ body, the limbs were not remarkable for their size.

‘ We see that organs, of which the nerves are so small ‘ that we cannot trace them by dissection, as the bones, the ‘ placenta, &c. grow as quickly as the other organs, in which ‘ the nerves are large and numerous.

‘ A year after I had cut across the sciatic nerve of a living frog, I could not perceive that limb smaller than the other ; ‘ yet it continued to be insensible and motionless. Nay, ‘ when I had broken the bones of the insensible limb, or ‘ wounded the skin and flesh, I found that the callus formed, ‘ and the wounds healed, as readily as if the nerve had been ‘ entire. The event was the same after dividing, transverse-

‘ ly, the lower or posterior end of the spinal marrow of the frog.

‘ It is well known,’ concludes our author, ‘ that, if powder of madder root is mixed with the food of a young animal, the bones become red ; or, if a bone has been broken, that the callus joining its parts will be red. The serum of the blood, in the first place, is deeply tinged ; but the red colour of the bones is not solely, nor even chiefly, owing to the coloured serum or blood circulating ; for I have found, that, after injecting water into the vessels till these were emptied of the blood, and that the water came out colourless, the tinge in the bones appeared equally deep, and was, therefore, plainly owing to a great quantity of the red earth added to the bones in the time of their growth. But this earth was not transmitted by the nerves ; for the colour of these, as I found, remained unchanged.’

That the nutritious particles of food are conveyed by the arteries, and applied by their extremities to the various parts of animal bodies which require to be repaired or expanded, is an opinion not only best supported by facts, but adopted by all the more rational physiologists. The principal facts and arguments in support of this theory shall now be mentioned.

The chyle, as formerly remarked, is converted into blood. The glutinous part of the blood, known by the name of *coagulable lymph*, resembles the white of an egg. That the white of an egg is the sole nourishment of the chick before its exclusion, is an established fact ; and the conclusion, from analogy, that the lymph of blood is destined for the growth and reparation of animal bodies, is by no means unnatural. ‘ Without repeating,’ says Dr. Monro, ‘ our extreme uncertainty as to the tubular nature of the nerves, and the im- probability that canals so exceedingly minute as those within the nerves must be, and of such length, are destined for

‘ the conveyance of glue, do we not find, that this very matter is separated by the exhalant branches of the arteries of the peritoneum, pleurae, and other shut sacs, and universally, by the branches of the arteries of the cellular membrane? The kinds of matter necessary for the growth and nourishment of our several organs are so various and different in their nature, that it is altogether incredible they can be furnished by the nerves: Thus, water is needed for the extension of the fore-part of the eye, viscid matter for the crystalline and vitreous humours, earth for the growth of the bones; &c.; whereas we can as easily conceive these to be furnished by the arteries, as that, in one place, they should furnish saliva, in another bile, &c. As the waste of the several organs is carried off by the vessels, either circulating or absorbent, why should we doubt that the circulating fluids can add a particle in the place of one that has been carried off, or that an artery can supply what has been absorbed by a lymphatic vein? As it is granted that the secretion of all other kinds of matter in the bodies of animals is performed by the branches of the arteries, is it not incredible that there should be an exception to the general rule in the secretion of the nourishment? Surely that power which can convert the food into blood, and can change the blood into bile and saliva, is sufficient to convert it into nourishment.

‘ I will now add,’ continues our author, ‘ that in calli, cicatrices, or accretions, there are numberless new formed vessels filled, in the living animal, with red blood, and which can readily be injected. Nay, I found by experiment, that such new formed vessels, produced by the opposite sides of a wound, unite into continued canals, or anastomose. If, then, in a callus, new earthy or osseous fibres, and new vessels, can be formed by the original arteries, must we not believe that the waste of this earth, and of these vessels,

'can be ever after supplied by the arteries which formed them? If so, are we not to conclude, that the waste of other arteries, and of other organs, is supplied in the same manner from the arteries? If the quantity of blood naturally circulating through a limb be diminished, as by tying the trunk of the brachial artery, in the operation for an aneurism, the arm loses part of its strength and size; but the loss is less than, at first sight, might be expected; because the anastomosing (or uniting) canals soon come to be greatly enlarged.

'Upon the whole,' the Doctor concludes, 'there are few points in physiology so clear, as, 1. That the arteries prepare, and directly secrete the nourishment in all our organs; and, 2. That the nerves do not contain nor conduct the nourishment, but, by enabling the arteries to act properly, contribute indirectly to nutrition.'

The ingenious Charles Bonnett endeavors to show, that the parts of all organised bodies are contained, in miniature, in germs or buds; that these germs, when placed in proper situations, gradually unfold and increase in magnitude; that the various members of animals and vegetables are expanded, both longitudinally and laterally, by food adapted to their respective natures; and that every germ actually includes the rudiments of the whole animals or vegetables which are to proceed from it during all successive generations.

With regard to vegetables, it is true, that the seed first produces a small tree, which it contained in miniature within its lobes. At the top of this small tree a bud or germ is formed, which contains the shoot or tree that is to spring next season. In the same manner, the small tree of the second year produces a bud which includes a tree for the third year; and this process uniformly goes on as long as the tree continues to vegetate. At the extremity of each

branch, buds are likewise formed, which contain, in miniature, trees similar to that of the first year. From these, and similar facts, it is concluded, that all these germs were contained in the original seed; for the first bud was succeeded by a similar bud, which was not unfolded till the second year, and the third bud was not expanded till the third year; and, of course, the seed may be said to have contained not only the whole buds which would be formed in a hundred years, but all the seeds, and all the individuals, which would successively arrive till the final destruction of the species.

These facts are known and established; but the reasoning deduced from them is fallacious, or, what amounts to the same thing, is perfectly incomprehensible. The seed is unquestionably the origin or cause of all future individuals, which may be infinite. But the idea that it really contained the germs of all the individuals, which were to spring from it as a source, is not only absurd, but exceeds all the powers of human imagination to conceive. Theories of this kind, of which there are too many in almost every department of science, hardly merit examination. Every seed, and every animal, according to this doctrine, includes in its own body an infinite posterity! If we assent to reasonings of this kind, we must lose ourselves in the labyrinths of infinity; and, instead of throwing light upon the subject, we shall involve it in tenfold darkness. All we know concerning the nature of growth and nutrition is extremely limited. We know that, in the animal kingdom, nutrition is performed by means of the blood, which is forcibly propelled through every part of the body by the action of the heart and arteries; and that vegetables, in a similar manner, are nourished by the ascension and distribution of the sap. But, how the nutritive particles are applied to the various parts of organized bodies, and how they expand the organs, or repair their continual

waste and loss of substance, we must content ourselves with remaining in perpetual ignorance.

In general, the food of animals, and particularly of the human species, consists of animal and vegetable substances, combined with water or other fluids. The Gentoo, and some other southern nations, live entirely upon vegetable diet. From the accounts we have of the different regions of the earth, it appears, that the natives of warm climates, where the cultivation of plants is practised, employ a greater proportion of vegetable food than in the more northern countries. The inhabitants of Lapland have little or no dependence on the fruits of the earth. They neither sow nor reap. They still remain, and, from the nature of their climate, must forever remain, in the shepherd state. Their comparative riches consist entirely of the number of reindeer possessed by individuals. Their principal nourishment is derived from the flesh and milk of these animals. In autumn, however, they catch great multitudes of fowls, most of them of the game kind. With these, while fresh, they not only supply their present wants, but dry and preserve them through the winter. They likewise kill hares, and other animals, which abound in the woods and mountains ; but the flesh of the bear is their greatest delicacy. In their lakes and rivers, they have inexhaustible stores of fishes, which, in summer and autumn, they dry in the sun, or in stoves, and in winter they are preserved by the frost. The Laplanders drink water, or animal oils ; but never taste bread or salt. They live in a pure air, and have sufficient exercise. Their constitutions are attempered to the coldness of the climate ; and they are remarkable for vigour and longevity. The gout, the stone, the rheumatism, and many other diseases which torture the luxurious in milder climes, are totally unknown to them. With the few gifts which Nature has bestowed on them, they remain satisfied, and live happily a-

mong their mountains and their storms. If southern nations afford examples of people who feed nearly on vegetables alone, the Laplanders furnish one of the opposite extreme; for they are almost entirely carnivorous animals.

To Norway, Sweden, Germany, and Britain, the same observation is applicable. In these countries, animal food is much more used than in France, Spain, Italy, Barbary, and the other southern regions of the globe. Many reasons may be assigned for these differences in the food of nations. The natural productions of the earth depend entirely on the climate. In warm climates, the vegetables which grow spontaneously are both more luxuriant and more various. The number and richness of their fruits far exceed those of colder regions. From this circumstance, the natives must be stimulated to use a proportionally greater quantity of vegetable food; and we learn from history, and from travellers, that this is actually the case. In cold countries, on the contrary, vegetables are not only fewer, but more rigid, and contain less nourishment. The inhabitants, accordingly, are obliged to live principally on animal substances. If we examine the mode of feeding in different nations, it will be found, that in proportion as men approach or recede from the poles, a greater or less quantity of animal and vegetable substances are used in their diet. Custom, laws, and religious rites, it must be allowed, produce considerable differences in the articles of food, among particular nations, which have no dependence on climate, or the natural productions of the earth. But when men are not fettered or prejudiced by extraneous circumstances, or political institutions, the nature of their food, is invariably determined by the climates they inhabit. The variety of food, in any country, is likewise greatly influenced by culture, and by imitation. Commerce occasionally furnishes new species of food, particularly of the vegetable kind. In Scotland, till about the beginning of this century, the common people lived almost entirely upon grain.

Since that period, the culture and use of the potatoe, of many species of coleworts, and of fruits, have been introduced, and universally diffused through the nation.

Whether man was originally intended by Nature to live solely upon animal or vegetable food ? is a question which has been much agitated both by the ancients and the moderns. Many facts and circumstances concur in establishing the opinion, that man was designed to be nourished neither by animals nor vegetables solely, but by a mixture of both. Agriculture is an art, the invention of which must depend on a number of fortuitous circumstances. It requires a long succession of ages before savage nations learn this art. They depend entirely for their subsistence upon hunting wild animals, fishing, and such fruits as their country happens spontaneously to produce. This has uniformly been the manner of living among all the savage nations of which we have any proper knowledge ; and seems to be a clear proof, that animal food is by no means repugnant to the nature of man. Besides, the surface of the earth, even in the most luxuriant climates, and though assisted by culture, is not capable of producing vegetable food in sufficient quantity to support the human race, after any region of it has become so populous as Britain, France, and many other nations. The general practice of mankind, when not restrained by prejudice or superstition, of feeding promiscuously on animal and vegetable substances, is a strong indication that man is, partly at least, a carnivorous animal. The Gentoos, though their chief diet be vegetables, afford no proper argument against this reasoning. They are obliged, by their religion, to abstain from the flesh of animals ; and they are allowed to use milk, which is a very nourishing animal food. Notwithstanding this indulgence the Gentoos, in general, are a meagre, sickly, and feeble race. In hot climates, however, a very great proportion of vegetable diet may be used without any bad consequences.

Other arguments, tending to the same conclusion are derived not from the custom or practices of particular nations, but from the structure of the human body. All animals which feed upon vegetables alone, as formerly remarked, have stomachs and intestines proportionally larger than those that live solely on animal substances. Man, like the carnivorous tribes, is furnished with cutting and canine teeth, and, like the graminivorous, with a double row of grinders. The dimensions of his stomach and intestines likewise hold a mean proportion between these two tribes of animals, which differ so essentially in their characters and manners.—From these and similar arguments, I have no hesitation to conclude, that a promiscuous use of animal and vegetable substances is no deviation from the original nature or destination of mankind, whatever country they may inhabit.

With regard to the different proportions of animal and vegetable food which are most accommodated to the health and vigour of mankind, no general rule can be given that could be applicable to different climates, and to the different constitutions of individuals. Animal food, it is certain, gives vigour to the body, and may be used more liberally by the active and laborious than those who lead a studious and sedentary life. A great proportion of vegetable food, and particularly of bread, is considered, by the most eminent physicians, as best adapted for men who are fond of science and literature; for full meals of animal food load the stomach, and seldom fail to produce dulness, yawning, indolence, and many diseases which often prove fatal.

The remainder of this chapter, from unavoidable causes, must consist of observations of a more desultory kind.

Most animals, when they live long on a particular species of food, are apt to be affected with diseases, which generally arise from costiveness, or its opposite. The guiney-pigs, after being confined for some time to coleworts, contract a looseness, which often terminates in death. But, when those

animals are at full liberty, they prevent this effect, by an instinct which teaches them to make frequent changes from moist to dry food: If they are restrained in their choice, they will eat, as a succedaneum, paper, linen, and even woollen cloths.

Though some animals, and many vegetables, would be noxious to man, if used as food, yet in general, that matter is more regulated by chance and custom than by rational motives. By experience, and the aid of our senses, we acquire a tolerable facility of distinguishing salutary from noxious food. Other animals select their food instinctively; and their choice is chiefly determined by the sense of smelling. The spaniel hunts his prey by the scent; but the grey-hound depends principally upon the use of his eye. When the grey-hound loses sight of a hare, he instantly gives up the chace, and looks keenly around him, but never applies his nose, in order to discover the track. Some rapacious animals, as wolves and ravens, discover carrion at distances, which, if we were to judge from our own sense of smelling, would appear to be altogether incredible. Others, as eagles, hawks, gulls, &c. surprise us no less by the acuteness of their sight. They perceive, from great heights in the air, mice, small birds, and minute fishes in the water.

One great cause of the diffusion of animals over every part of the globe, is to be derived from the diversity of appetites for particular species of food, implanted by Nature in the different tribes. Some fishes are only to be found in certain latitudes. Some animals inhabit the frigid, others the torrid zones; some frequent deserts, mountains, woods, lakes, and meadows. In their choice of situation, they are uniformly determined to occupy such places as furnish them with food accommodated to their natures. Monkies, the elephant, and rhinoceros, fix on the torrid zone, because they feed on vegetables which flourish there during the

whole year. The rein-deer inhabit the cold regions of the north, because these countries produce the greatest quantity of the lichen, a species of moss, which is their beloved food. The pelican makes choice of dry and desert places to lay her eggs. When her young are hatched, she is obliged to bring water to them from great distances. To enable her to perform this necessary office, Nature has provided her with a large sac, which extends from the tip of the under mandible of her bill to the throat, and holds as much water as will supply her brood for several days. This water she pours into the nest to cool her young, to allay their thirst, and to teach them to swim. Lions, tigers, and other rapacious animals, resort to these nests, drink the water, and are said not to injure the young *. The goat ascends the rocky precipice, to crop the leaves of shrubs, and other favourite plants. The sloth and the squirrel feed upon the leaves and the fruit of trees, and are, therefore, furnished with feet which enable them to climb. Water-fowls live upon fishes, insects, and the eggs of fishes. Their bill, neck, wings, legs, and whole structure, are nicely fitted for enabling them to catch the food adapted to their natures. Their feeding upon the eggs of fishes accounts for that variety of fishes which are often found in lakes and pools on the tops of hills, and on high grounds remote from the sea and from rivers. The bat and the goat-sucker fly about during the night, when the whole air is filled with moths, and other nocturnal insects. The bear, who acquires a prodigious quantity of fat during the summer, retires to his den, when provisions fail him, in winter. For some months, he receives his sole nourishment from the absorption of the fat which had been previously accumulated in the cellular membrane.

A glutton, brought from Siberia to Dresden, eat every day, says M. Klein, thirty pounds of flesh without being sat-

* *Amoen. Acad.*, vol. 2, p. 41.

isfied. This fact indicates an amazing digestive power in so small a quadruped ; for the story of his squeezing his sides between two trees, in order to make him disgorge, is a mere fable*.

Siberia, Kamtschatka, and the polar regions, are supposed to be the abodes of misery and desolation. They are, it must be allowed, infested with numerous tribes of bears, foxes, gluttons, and other rapacious animals. But it should be considered, that these voracious animals supply the natives with both food and clothing. To elude the attacks of ferocity, and to acquire possession of the skins and carcasses of such creatures, the industry and dexterity of savage nations are excited. The furs are demanded by foreigners. The inhabitants by this means learn commerce and the arts of life ; and, in the progress of time, bears and wild beasts become the instruments of polishing a barbarous people. Thus, the most substantial good often proceeds from apparent misfortune.

There is hardly a plant that is not rejected as food by some animals, and ardently desired by others. The horse yields the common water-hemlock to the goat, and the cow the long-leaved water-hemlock to the sheep. The goat, again, leaves the aconite, or bane-berries, to the horse, &c. Plants which afford proper nourishment to some animals, are by others avoided, because they would not only be hurtful, but even poisonous. Hence no plant is absolutely deleterious to animal life. Poison is only a relative term. The euphorbia, or spurge, so noxious to man, is greedily devoured by some of the insect tribes.

It is a maxim universally received, that every animal, after birth, grows, or acquires an augmentation of size. The spider-fly, however, affords an exception. The mother lays an egg so disproportionately large, that no person, without

* *Gaz. Literaire*, vol. i., page 481.

the aid of experience, could believe it to have been produced by this insect. When the egg is hatched, a fly proceeds from it, which, at the moment of birth, equals the parent in magnitude. Upon a stricter examination of this egg, it has been discovered, that the insect, while in the belly of its mother, undergoes a transformation into the nymph or chrysalis state ; and that, instead of a worm, a fly is produced from it, of the same dimensions as the parent. This discovery, however, does not diminish our wonder, that any animal should actually give birth to a substance as large as its own body, and that its size should never afterwards receive any augmentation*.

When caterpillars, some time before their change, are deprived of food, they diminish to at least one half of their former size. Their chrysalids, of course, as well as the butterflies which proceed from them, are proportionally small. From this fact we learn the importance of feeding all young animals well till they acquire their full growth.

It is a remark of the ingenious Reaumur, that such insects as feed upon dead carcases, and whose fecundity is great, never attack live animals. The flesh-fly deposits her eggs in the bodies of dead animals, where her progeny receive that nourishment which is best suited to their constitution. But this fly never attempts to lay her eggs in the flesh of sound and living animals. If Nature had determined her to observe the opposite conduct, men, quadrupeds, and birds, would have been dreadfully afflicted by the ravages of this single insect. Lest it might be imagined that the flesh-fly selected dead, instead of live animals, because, in depositing her eggs, she was unable to pierce the skin of the latter, M. de Reaumur made the following experiment, which removed every doubt that might arise on the subject. He carefully pulled off all the feathers from the thigh of a young

* R^eaumur, tom. 6. p. 48. ;—and Bonnet, tom. 3. p. 363.—369.

pigeon, and applied to it a thin slice of beef, in which there were hundreds of maggots. The portion of beef was not sufficient to maintain them above a few hours. He fixed it to the thigh by a bit of gauze ; and he prevented the pigeon from moving, by tying its wings and legs. The maggots soon shewed that their present situation was disagreeable to them. Most of them retired from under the slice of beef ; and the few that remained perished in a short time. Their death was probably occasioned by the degree of heat in the pigeon's body being greater than their constitution could bear. Upon the same pigeon M. de Reaumur performed another experiment. He took off the skin from its thigh, laid bare the flesh, and applied immediately another slice of beef full of maggots. The animals discovered evident marks of uneasiness ; and all of them that remained on the flesh of the pigeon were deprived of life, as in the former experiment, in less than an hour. Thus the degree of heat that is necessary to such worms as inhabit the interior parts of animals, is destructive to those species which Nature has destined to feed upon the flesh of dead animals. Hence the worms sometimes found in ulcerous sores, must belong to a different species from those upon which the above experiments were made.

The growth of some worms, which feed upon animal or vegetable substances, is extremely rapid. Redi remarked, that these creatures, the day after they escaped from the egg, had acquired at least double their former size. At this period he weighed them, and found that each worm weighed seven grains ; but that, on the day preceding, it required from twenty-five to thirty of them to weigh a single grain. Hence, in about the space of twenty-four hours, each of these worms had become from 155 to 210 times heavier than formerly. This rapidity of growth is remarkable in

those maggots which are produced from the eggs of the common flesh-fly.

Before we dismiss this subject, a few observations on that power, inherent in all animal bodies, of dissolving, and converting into chyle, every nutritive substance thrown into the stomach, merit attention.

In order to explain the process of digestion, some physicians and philosophers have had recourse to mechanical force, and others to chemical action. The supporters of mechanical force, maintained, that the stomachs of all animals comminuted, or broke down into small portions, every species of food, and prepared it for being converted into chyle. The chemical philosophers, on the contrary, supported the opinion, that the food was dissolved by a fermentation induced by the saliva and gastric juices. The disputes which naturally arose from these seemingly opposite theories, stimulated the inquiries of the ingenious, and produced several curious and important discoveries. Reaumur, M'Bride, Stevens, Spalanzani, Hunter, have all exerted their industry and talents upon this subject. To give even an abridged view of their different labours would be both tedious, and, at the same time, would not coincide with the design of this work. I shall therefore confine myself to some results of their experience and labours. Spalanzani, who is a voluminous writer on this subject, relates not only the discoveries of his predecessors, but has enriched his work with numerous experiments and observations made by himself. In his investigation of the process of digestion, and the action of the stomach, he observes the following order :

1. He treats of animals with strong muscular stomachs, as common fowls, turkeys, ducks, geese, pigeons, &c. 2. Of animals with stomachs of an intermediate consistence, as crows, herons, &c. 3. Of animals with membranous stomachs, as frogs, lizards, earth and water snakes, vipers, fishes,

sheep, the ox, the horse, the owl, the falcon, the eagle, the cat, the dog, man, &c.

With regard to birds which are furnished with muscular stomachs, or gizzards, Spalanzani, in imitation of Reaumur, procured small glass and metal balls and tubes, perforated with many holes. These he filled with different kinds of food, and forced them down the throats of common fowls, turkeys, &c. He filled balls with barley, or other grains, in their entire state, and allowed them to remain in the stomachs of ducks, turkeys, and other fowls, for twenty-four, and, in some cases, for forty-eight hours. He then killed the animals, took the balls out of their stomachs, and after examining the grains attentively, he could not discover that the gastric juice, to the action of which they were fully exposed by the numerous holes in the balls, had made the smallest impression upon them. They suffered no diminution of size, and exhibited no marks of dissolution. These experiments he often repeated upon a number of fowls provided with muscular stomachs, and the event was uniformly the same: In no instance did the gastric juice produce any solvent effect upon the grain contained in the balls. After these unsuccessful attempts, he suspected, that, though the gastric juice was unable to dissolve grains in their entire state, it might act as a menstruum upon them when sufficiently masticated or bruised. To ascertain this point, he afterwards filled his balls with bruised grains, and introduced them into the stomachs of different fowls, as cocks, ducks, turkeys, wood-pigeons, &c. In all the numerous trials he made with bruised grain, he invariably found, that the grain was more or less dissolved in proportion to the time the balls were allowed to remain in the stomach.

Reaumur and Spalanzani, in the course of their experiments upon the digestion of birds with muscular stomachs, discovered a wonderful communicating force which these stomachs possess. When tin tubes full of grain were thrown

into the stomachs of turkeys, and allowed to continue there a considerable time, they were found to be broken, crushed, or distorted, in a most singular manner. ‘Having found,’ says Spalanzani, ‘that the tin tubes which I used for common fowls were incapable of resisting the stomach of turkeys, and not happening at that time to be provided with any tin plate of greater thickness, I tried to strengthen them, by soldering to the ends two circular plates of the same metal, perforated only with a few holes for the admission of the gastric fluid. But this contrivance was ineffectual; for, after the tubes had been twenty hours in the stomach of a turkey, the circular plates were driven in, and some of the tubes were broken, some compressed, and some distorted, in the most irregular manner*.’

The smooth and blunt substances formerly employed, Spalanzani remarks, though so violently acted upon, could not injure the stomach; he therefore tried what effects would be produced by sharp bodies thrown into the gizzards of fowls. He found that the stomach of a cock, in the space of twenty-four hours, broke off the angles of a piece of rough jagged glass. Upon examining the gizzard, no wound or laceration appeared. ‘Twelve strong tin needles,’ says Spalanzani, ‘were firmly fixed in a ball of lead, the points projecting about a quarter of an inch from the surface. Thus armed, it was covered with a case of paper, and forced down the throat of a turkey. The bird retained it for a day and a half without showing the least symptom of uneasiness. Why the stomach should have received no injury from so horrid an instrument I cannot explain: The points of the twelve needles were broken off close to the surface of the ball, except two or three, of which the stumps projected a little higher. Two of the points of the needles were found among the food; the other ten I could

* Spalanzani’s *Dissertations*, vol. 1. p. 12.

‘ not discover, either in the stomach or the long track of the intestines ; and therefore concluded, that they had passed out at the vent *.’

The same author made a second experiment seemingly still more cruel. He fixed twelve small lancets, very sharp both at the points and edges, in a similar ball of lead. ‘ The lancets,’ says he, ‘ were such as I use for the dissection of small animals. The ball was given to a turkey cock, and left eight hours in the stomach ; at the expiration of which time that organ was opened ; but nothing appeared except the naked ball, the twelve lancets having been broken to pieces. I discovered three of them in the large intestines, pointless, and mixed with the excrements ; the other nine were missing, and had probably been voided at the vent. The stomach was as found and entire as that which had received the needles. Two capons, of which one was subjected to the experiment with the needles, and the other with the lancets, sustained them equally well.’

The small stones so commonly found in the stomachs of many of the feathered tribes, have been supposed to sheath the gizzard, and to enable it to digest, or at least to break down into small fragments, glass, iron, wood, stones, and other hard, and even sharp-pointed substances. Spalanzani has endeavoured to prove, that the muscular action of the gizzard is equally powerful, whether the small stones are present or absent. To ascertain this point, he took wood-pigeons the moment they escaped from the egg, fed and nursed them himself till they were able to peck : ‘ They were then,’ continues our author, ‘ confined in a cage, and supplied at first with vetches soaked in warm water, and afterwards in a dry and hard state. In a month after they had begun to peck, hard bodies, such as tin tubes, glass globules, and fragments of broken glass, were introduced with the food. Care was taken that each pigeon should swallow on-

* Spalanzani’s Diff. vol. 1. page 18.

' ly one of these substances. In two days afterwards they were killed. Not one of the stomachs contained a single pebble ; and yet the tubes were bruised and flattened, and the spherules and bits of glass blunted and broken : This happened alike to each body ; nor did the smallest laceration appear on the coats of the stomach.' From several experiments of a similar nature, and accompanied with the same events, Spalanzani concludes this subject with that candour which is always a genuine characteristic of a real philosophic spirit. Upon the whole, ' it appears,' says he, ' that these small stones are not at all necessary to the trituration of the firmest food, or the hardest foreign substance, contrary to the opinion of many anatomists and physiologists, as well ancient as modern. I will not, however, deny, that, when put in motion by the gastric muscles, they are capable of producing some effect on the contents of the stomach.'

The celebrated Mr. John Hunter, in his *Observations on Digestion**, fairly quotes the modest conclusion of Spalanzani. But he insists that stones are extremely useful in the comminution of grain, and other substances, which constitute the food of many fowls. ' In considering,' Mr. Hunter remarks, ' the strength of the gizzard, and its probable effects when compared with the human stomach, it must appear that the gizzard is, in itself, very fit for trituration. We are not, however, to conclude, that stones are entirely useless ; for, if we compare the strength of the muscles of the jaws of animals who mastigate their food, with those of birds who do not, we shall say, that the parts are well calculated for the purpose of mastication ; yet we are not from thence to infer, that the teeth in such jaws are useless, even although we have proof that the gums do the business when the teeth are gone. If stones are of use, which

* Page 156.

we may reasonably conclude they are, birds have an advantage over animals having teeth, so far as stones are always to be found, while the teeth are not renewed. If we constantly find in an organ substances which can only be subservient to the functions of that organ, should we deny them that use, although the part can do its office without them? The stones assist in grinding down the grain, and, by separating its parts, allow the gastric juice to come more readily in contact with it.'

The next series of experiments were made upon animals with what Spalanzani denominates intermediate stomachs between the muscular and membranous, as ravens, crows, herons, &c. The power and action of these intermediate stomachs are superior to those of the membranous kind, but greatly inferior to those of the muscular. The tin tubes, or balls, which pigeons and turkeys soon flatten and disfigure, remain unaltered in the stomach of crows. Their gastric muscles, however, are by no means inert. Though they are unable to compress or distort tin tubes, they are capable of producing this effect upon thin tubes of lead. Birds whose stomachs are of an intermediate kind, with regard to the thickness and strength of their muscular coats, may be denominated *omnivorous*. They eat grass, herbs, grain, and flesh of every kind. When we make experiments, upon the digestive powers of gallinaceous birds, the animals must be killed before we can learn what effects have been produced on the substances inclosed in the balls or tubes. But, on crows and ravens, experiments of this kind may be repeated as often as we please, without destroying a single individual. Substances which they are incapable of digesting; as metallic tubes, they have the power of disgorging, or returning by the mouth, in the same manner as falcons, and other birds of prey, throw up the feathers and hair of the animals they have devoured. In birds of prey, this vomiting is common-

ly performed every twenty-four hours ; but, in crows, it happens at least every nine, and not unfrequently every two or three hours.

Spalanzani, as in the former experiments, thrust down perforated tubes, filled with different substances, into the stomachs of crows. These tubes were uniformly thrown up by the animals in a few hours. When the tubes were filled with entire grains, as wheat or beans, he found that the gastric juice, though the tubes, being repeatedly forced down, continued in the stomach for the space of forty-eight hours, had exerted no solvent power. As the husks of the seeds resisted the action of the gastric juice, he bruised them, and repeated the experiment. ‘ Four tubes full of this coarse ‘ flour,’ says he, ‘ were given to a crow : They remained ‘ eight hours in the stomach, and proved the justness of my ‘ suspicion ; for, upon examining the contents, I found a- ‘ bove a fourth part wanting. This could arise from no ‘ other cause but solution in the gastric liquor, with which, ‘ the remainder was fully impregnated. Another observa- ‘ tion concurred in proving the same proposition : The larg- ‘ est bits of wheat and bean were evidently much diminish- ‘ ed : This must have been owing to the gastric liquor hav- ‘ ing corroded and dissolved good part of them, as the nitrous ‘ acid, diluted with a large quantity of water, gradually con- ‘ sumes calcareous substances. I replaced what remained of ‘ the seeds in the tubes, and committed them again to the ‘ stomach, wherein they remained, at different intervals, ‘ twenty-one hours ; at the end of which period they were ‘ entirely dissolved ; nothing being left but some pieces of ‘ husk, and a few inconsiderable fragments of the seeds. ‘ Wheat and beans floating loose in the cavity of the stom- ‘ ach, undergo the same alteration as in the tubes. When ‘ I fed my crows with these seeds, I observed, that, before ‘ they swallowed them, they set them under their feet, and

reduced them to pieces by repeated strokes of their long and heavy beaks : And now they digested them very well ; nay, this process was very rapid in comparison of that which took place within the tubes. But, when the birds, either from excessive hunger, or violence, swallowed the seeds entire, the greatest part of them passed out entire at the anus, or were vomited. We cannot, therefore, be surprised, that the gastric juice could not dissolve them within the tubes, since it was incapable of effecting this process within the cavity of the stomach, where its solvent power is far superior.'

Similar experiments were made with French beans, peas, nut-kernels, bread, apples, and different kinds of flesh and fish, all of which were dissolved, both in tubes, and in the cavity of the stomach, by the gastric juice.

Spalanzani finishes his experiments on digestion with those animals which have thin membranous stomachs. This class comprehends an immense number of species, as man, quadrupeds, fishes, reptiles. In these the coats of the stomach seem to have little or no action upon their contents, the gastric juice being fully sufficient to break down the food, and reduce it to a pulp.

With regard to man, Dr. Stevens, in an Inaugural Dissertation concerning Digestion, published at Edinburgh in the year 1777, made several experiments upon a German, who gained a miserable livelyhood by swallowing stones for the amusement of the people. He began this strange practice at the age of seven, and had at that time continued it about twenty years. He swallowed six or eight stones at a time, some of them as large as a pigeon's egg, and passed them in the natural way. Dr. Stevens thought this poor man would be an excellent subject for ascertaining the solvent power of the gastric juice in the human stomach. The Doctor, accordingly, made use of him for this purpose. He made the

German swallow a hollow silver sphere, divided into two cavities by a partition, and perforated with a great number of holes, capable of admitting an ordinary needle. Into one of these cavities he put four scruples and a half of raw beef, and into the other five scruples of raw bleak. In twenty-one hours the sphere was voided, when the beef had lost a scruple and a half, and the fish two scruples. A few days afterwards, the German swallowed the same sphere, which contained, in one cavity, four scruples and four grains of raw, and, in the other, four scruples and eight grains of boiled beef. The sphere was returned in forty-three hours : The raw flesh had lost one scruple and two grains, and the boiled one scruple and sixteen grains. Suspecting that, if these substances were divided, the solvent would have a freer access to them, and more of them would be dissolved. Dr. Stevens procured another sphere, with holes large enough to receive a crow's quill. He inclosed some beef in it a little masticated. In thirty-eight hours after it was swallowed, it was voided quite empty. Perceiving how readily the chewed meat was dissolved, he tried whether it would dissolve equally soon without being chewed. With this view, he put a scruple and eight grains of pork into one cavity, and the same quantity of cheese into the other. The sphere was retained in the German's stomach and intestines forty-three hours ; at the end of which time, not the smallest quantity of either pork or cheese was to be found in the sphere. He next swallowed the same sphere, which contained, in one partition, some roasted turkey, and some boiled salt herring in the other. The sphere was voided in forty-six hours ; but no part of the turkey or herring appeared ; for both had been completely dissolved. Having discovered that animal substances, though inclosed in tubes, were easily dissolved by the gastric juice, the Doctor tried whether it would produce the same effect upon vegetables. He, therefore, inclosed an

equal quantity of raw parsnep and potatoe in a sphere. After continuing forty-eight hours in the alimentary canal, not a vestige of either remained. Pieces of apple and turnip, both raw and boiled, were dissolved in thirty-six hours.

It is a comfortable circumstance, that no animal, perhaps, except those worms which are hatched in the human intestines, can resist the dissolving power of the gastric juice. Dr. Stevens inclosed live leeches, and earth-worms, in different spheres, and made the German swallow them. When the spheres were discharged, the animals were not only deprived of life, but completely dissolved, by the operation of this powerful menstruum. Hence, if any live reptile should chance to be swallowed, we have no reason to apprehend any danger from such an accident.

The German left Edinburgh before the Doctor had an opportunity of making a farther progress in his experiments. He therefore had recourse to dogs and ruminating animals. In the course of his trials upon the solvent power in the gastric fluid of dogs, he found that it was capable of dissolving hard bones, and even balls of ivory ; but that, in equal times, very little impression was made upon potatoes, parsnep, and other vegetable substances. On the contrary, in the ruminating animals, as the sheep, the ox, &c. he discovered, that their gastric juice speedily dissolved vegetables, but made no impression on beef, mutton, and other animal bodies. From these last experiments, it appears that the different tribes of animals are not less distinguished by their external figure, and by their manners, than by the quality and powers of their gastric juices. Dogs are unable to digest vegetables, and sheep and oxen cannot digest animal substances. As the gastric juice of the human stomach is capable of dissolving, nearly with equal ease, both animals and vegetables, this circumstance affords a strong and almost an irresistible, proof, that Nature originally intended man to feed promiscuously upon both.

Live animals, as long as the vital principle remains in them, are not affected by the solvent powers of the stomach. ‘Hence it is,’ Mr. Hunter remarks, ‘that we find animals of various kinds living in the stomach, or even hatched and bred there; but the moment that any of these lose the living principle, they become subject to the digestive powers of the stomach. If it were possible, for example, for a man’s hand to be introduced into the stomach of a living animal, and kept there for some considerable time, it would be found that the dissolvent powers of the stomach could have no effect upon it: But, if the same hand were separated from the body, and introduced into the same stomach, we should then find, that the stomach would immediately act upon it. Indeed, if this were not the case, we should find that the stomach itself ought to have been made of indigestible materials; for, if the living principle was not capable of preserving animal substances from undergoing that process, the stomach itself would be digested. But we find on the contrary, that the stomach, which at one instant, that is, while possessed of the living principle, was capable of resisting the digestive powers which it contained, the next moment, viz. when deprived of the living principle, is itself capable of being digested, either by the digestive powers of other stomachs, or by the remains of that power which it had of digesting other things.’

When bodies are opened some time after death, a considerable aperture is frequently found at the greatest extremity of the stomach. ‘In these cases,’ says Mr. Hunter, ‘the contents of the stomach are generally found loose in the cavity of the abdomen, about the spleen and diaphragm. In many subjects, this digestive power extends much farther than through the stomach. I have often found, that, after it had dissolved the stomach at the usual place, the contents of the stomach had come into contact with the

' spleen, and diaphragm, had partly dissolved the adjacent side of the spleen, and had dissolved the stomach quite through ; so that the contents of the stomach were found in the cavity of the thorax, and had even affected the lungs in a small degree.'

CHAPTER IX.

Of the Sexes of Animals and Vegetables.



SECTION I.

Of the Sexes of Animals.

ALL the larger and more perfect animals are distinguished by the sexes of male and female. The bodies of males, though not without exceptions, are, in general, stronger, larger, and more active, than those of the females. In the human species, the male is not only larger than the female, but his muscular fibres are firmer and more compact, and his whole frame indicates a superior strength and robustness of texture. He does not acquire his full growth, and best form, till he arrives at the age of thirty years. But, in women, the parts are rounder, and their muscular fibres more feeble and lax than those of men, and their growth and form are perfect at the age of twenty. A similar observation is applicable to the minds of the two sexes. Man is, comparatively, a bold, generous, and enterprising animal. Women, on the contrary, are timid, jealous, and disposed to actions which require less agility and strength. Hence they are entitled to claim, and, by their amiable weaknesses, they actually receive our protection. Men are endowed with majesty of figure and force of mind ; but beauty, and the graces, are the proper characteristics of women. The laxity and softness of their texture may, in some measure, account for the timidity and listlessness of their disposition ; for, when the bodies of men are relaxed by heat, or by any other cause, their minds become not only timid, but weak, undetermined, and inactive.

The social intercourse of women softens the dispositions, and soothes the cares and labours of the men. Their little female humours, caprices, and follies, give rise to many exertions of virtue. They excite in us compassion, humanity, and tenderness of affection. The delicacy of their bodies, and the weakness of their minds, require our support and protection. In return, the gentle and insinuating manners of the women have a direct tendency to soften and smooth the natural roughness of men. In most governments, women have the entire management and training of children, till their characters and dispositions are almost fixed for life. This is an important office ; and would require more education and sense than they commonly receive either from nature or art. But their persevering and unremitting attention to their charge, especially when children are sick or weakly, is so truly astonishing, that no man could have patience to perform the laborious and painful task. Women are likewise said to suffer bodily pain with more resolution than men. Women reason rapidly ; but their reasoning, though often acute, is seldom solid.

Modesty is one of the most distinguishing and attractive characteristics of the female sex. This is the great defence with which Nature has armed them against the artifices and deceit of the males. Modesty has a double effect : It both attracts and repels. It heightens the desire of the male, and deters him from rudeness, or improper behaviour. Were women deprived of this amiable quality, all their charms would vanish, and the ardour of love would be extinguished. It is, therefore, not only the interest of females to cultivate modesty, but to guard, with the most anxious attention, against the smallest incroachments. Every attack, however apparently insignificant, should be repelled with spirit and intrepidity. To men of sensibility, a single glance of the eye will tell them that their conduct is improper, and make them not on-

ly instantly desist, but prevent every future attempt. There is no part of the female character which men revere so much as modesty. It is the brightest and most valuable jewel with which a woman can be adorned. A fine woman without modesty, instead of gaining the affections of men, becomes an object of contempt, and even of disgust. It is equally the interest of men to cherish, and not to injure by indelicacy, a quality from which they derive so much pleasure and advantage.

It is not unworthy of remark, that modesty is by no means confined to the human species. Evident traces of it are discoverable in the brute creation. Even so low as the insect tribes, most females repel the first attacks of the males. If this is not modesty, it has all the effects of it ; for it heightens the respect and affection of the males, and makes them employ every alluring art to procure the regard of the female.

It is a curious fact, that most carnivorous quadrupeds are more averse from devouring women than men. The bears of Kamtschatka follow the women when gathering wild fruits in the woods, and, though most rapacious animals, do them no farther harm than robbing them of part of the fruit*. The aspect of man being more bold, may, perhaps, create an idea of competition and danger, and excite the ferocity and courage of the animal. There seems to be instinctive respect, if not dread, of the human kind implanted in most animals. If this be the case, the above fact amounts to a high compliment to the women ; for they receive more favour from the brute creation than the men.

With regard to animals, in general, the intercourse of sexes is necessary for the multiplication of the species. But, as formerly remarked†, several of the lower tribes are enabled to multiply without the intervention of sexes. In some ani-

* Gazette Literaire, vol. I. page 482. † See chap. I. page 30. &c.

imals, both sexes are combined in each individual. The earth-worm, snails, and several shell-fishes, are hermaphrodites; and yet the conjunction of two is necessary for their multiplication. Mr. Adanson, in his account of Senegal, mentions some shell-animals which, in order to produce, require the union of three individuals. In the polypus, no appearance of sexual distinction has hitherto been discovered. Nature, however, has not denied them the power of multiplication, which is effected in a very singular manner*. Caterpillars of every denomination are totally destitute of sexes, and are incapable, while they remain in that state, of multiplying their species. But, after their transformation into flies, the distinction of sexes is apparent, and their fertility is exceedingly great.

Among the larger animals, the difference of size and figure between males and females is not remarkable. The most striking distinctions arise from the horns, the tusks, the crest, &c. which adorn the head of the male, and are often wanting in the female. But, among the insect tribes, some males differ so greatly from the females, that they have the appearance of belonging to a separate genus. In some butterflies, for example, the female is destitute of wings, while those of the male are very large. The male and female of those animals called *gall-insects* bear no proportion to each other, either in size or in figure. They adhere for several months to the stems and branches of plants, shrubs, and trees, without any apparent movement. They have every appearance of galls, being of a spherical or oval figure, from which circumstance they have received their denomination, and were long considered as vegetable substances destitute of every degree of animation. Reaumur, however, by a strict examination of the changes they undergo, and of their internal structure, discovered that they belong to the animal

* See chap. I. page 30, &c.

kingdom. He found that they contained thousands of small eggs, and that, from these eggs, small animals were produced, which ran about with some quickness, and spread themselves all over the tree or bush. After some days, they attach themselves to the stem and branches, remain immovable, and gradually increase to their full dimensions, when their bodies are found to contain numbers of eggs. As the perfect animal had no apparent motion, and yet multiplied its species, it was first thought to be an hermaphrodite of a singular kind, and that it was capable of producing without any foreign aid. But Reaumur discovered that they were impregnated by small flies, and these small flies were male gall-insects. The head, the body, the breast, and the six limbs of this fly, are of a deep and red colour ; and the wings, which are proportionally large, are white, and bordered with a band of fine carmine red. In the month of April, he perceived numbers of these flies wandering about on the gall-insects. He observed that they pierced the covering of the gall-insects with a kind of sting shaped like a needle. This circumstance created a suspicion that these flies were the males, and that this was their mode of impregnating the eggs of the female. To ascertain this point, he opened a number of gall-insects, which had no uncommon appearance, and, in some of them, he found the males, in every stage of their existence, till they pierced the external covering, came out in the form of perfect flies, and attached themselves, as usual, to the females. The glow-worm, an animal condemned to crawl perpetually on the surface of the earth, is a female ; and the male instead of a reptile, is a scarabaeus, or beetle, furnished with four wings. A species of phosphorus, emitted from the body of the female, excites the attention of this apparently strange male, who darts down upon her, and actually enables her to continue the kind*. The female of another species of beetle is a perfect

* Reaumur, *Oeuvres de Bonnet*, tom. 2. page 87. edit. 8vo.

reptile, and has not the smallest vestige of wings. But the male is a real beetle with four wings, and is so disproportioned to the female in size, that their junction should appear to be equally singular as that of a ram with an elephant. With regard to the pucerons, or vine-fretters, the males are winged; but the females remain during life totally destitute of wings. In some species of them, however, the females have wings, and these instruments of motion are denied to the males. Between the size of the male and female pucerons, there is likewise a remarkable disproportion. The males, particularly those which have no wings, are so comparatively small, that they run about, like the male gall-insects, upon the backs of the females. While this exercise continues, which is often very long, the female remains almost motionless. The more insensibility and listlessness shown by the female, the male exhibits the greater ardour and agility. In this situation he passes whole days without taking any nourishment.

In birds of prey, the females are larger, stronger, fiercer, and more beautiful than the males. This superiority of strength and magnitude is conferred on the females, because, in general, they are obliged to procure food both for themselves and for their progeny. Vultures, however, are to be excepted; for the males are equal in size, if they do not exceed that of the females. In the gallinaceous tribe of birds, on the contrary, the males are larger, more beautiful, and more courageous, than the females. The peacock, the turkey, the pheasant, and the dunghill cock, are remarkable examples. Dunghill cocks, especially that kind of them which are called *game-cocks*, are the most intrepidly bold and high-spirited animals in the creation. Nothing but absolute death can make them yield to an antagonist. In the domestic state, at least, this intrepidity, and this daring spirit, result from competition, and jealousy of rivals. Game-cocks,

to the disgrace of humanity, are fed and trained with the most scrupulous attention. For what purpose? For the cruel amusement and fortuitous emolument of gamblers.

That there are natural hermaphrodites, I have formerly mentioned. But, in man, dogs, cats, unnatural hermaphrodites, if they ever exist, are so rare, that the celebrated anatonomist, Mr. Hunter, declares he never saw a single example. But, in the horse, the asfs, black-cattle, and sheep, he has seen many hermaphrodites. It is said to be a known fact, that, when a cow brings forth two calves, one of them a male, and the other a female, the female is incapable of propagation, but that the male is a perfect animal. In England, a cow-calf brought forth with a bull-calf is denominated a *free martin*, and is as well known among farmers as either cow or bull. Mr. Hunter remarks, that a cow-calf, brought forth in the situation above mentioned, may be either a free martin or a perfect female. ‘For,’ he remarks, ‘I have reason to believe, that, in black cattle, such a deviation may be produced without the circumstance of twins; and, even when there are twins, the one a male, the other a female, they may both have the organs of generation perfectly formed*.’ What is called a *free martin*, or imperfect hermaphrodite, as far as observation has hitherto extended, is confined to black-cattle. The free martin has all the external characteristics of a female calf. When animals of this description are preserved by farmers, it is not for the purpose of propagation, but for yoking with the oxen, or fattening for the table. They neither breed, nor, what is curious, do they discover the smallest inclination for the male, nor does the bull pay the least attention to them.

The free martin, in figure, resembles the ox, or spayed heifer. It is considerably larger than the bull or cow, and its horns are similar to those of the ox. ‘The belly of the

* Hunter’s Observations on the Animal Oeconomy, page 49.

‘ free martin,’ says Mr. Hunter, ‘ is similar to that of an ox, having more resemblance to that of the cow than of the bull. Free martins are very susceptible of growing fat with food. The flesh, like that of the ox, or spayed heifer, is in common much finer in the fibre than either the bull or cow, and is supposed to exceed that of the ox or heifer in delicacy of flavour, and bears a higher price at market*.’ The Romans seem to have had some knowledge of free martins, though they have not transmitted to us any peculiarities in the structure of these animals. With them, *taurus* was the generic name of the ox kind. They likewise mention *taurae*, by which, it is thought, they meant barren cows. Columella, when talking of cattle, says, ‘ and, like the *taurae*, which occupy the place of *fertile* cows, should be rejected.’ Varro likewise informs us, that ‘ the cow which is barren is called *taura*.’

Mr. Hunter gives an anatomical description of three free martins, the most perfect of which we shall transcribe.

‘ *Mr. Arbuthnot’s Free Martin*†.

‘ The external parts were rather smaller than in the cow. The vagina passed on, as in the cow, to the opening of the urethra, and then it began to contract into a small canal, which passed on to the division of the uterus into two horns; each horn passed along the edge of the broad ligament laterally towards the ovaria. At the termination of these horns were placed both the ovaria and the testicles; both were nearly of the same size, which was about as large as a small nutmeg. To the ovaria I could not find any Fallopian tube. To the testicles were vasa deferentia; but they

* Hunter’s Observations on the Animal Oeconomy, p. 50. † Columella. lib. 6. chap. 22.

‡ ‘ This animal was seven years old, had been often yoked with the oxen, at other times went with the cows and bull, but never showed any desire for either the one or the other.’

‘ were imperfect. The left one did not come near the testicle ; the right one came close to it, but did not terminate in a body called the epididymis. They were both pervious, and opened, into the vagina near the opening of the urethra. On the posterior surface of the bladder, or between the uterus and bladder, were the two bags called *vesiculae seminales* in the male, but much smaller than what they are in the bull : The ducts opened along with the *vasa deferentia**?

* Hunter's Observations on the Animal Oeconomy, page 52.

SECTION II.

Of the Sexes of Plants.

WHEN an hypothesis, or theory, has obtained a general reception among even the enlightened part of mankind, it is extremely difficult to eradicate the prejudice, either by arguments or by facts. There is not a notion more generally adopted, than that vegetables have the distinction of sexes, and that the influence of what is called the male is indispensably necessary to the fecundation of the female, or seed-bearing plant : A notion which I have long considered as a striking example of the danger of rashly yielding assent to the alluring seductions of analogical reasoning*.

Every person who is acquainted with the sexual theory of vegetables, and with the arguments by which it is defended, must acknowledge, that its principal support is derived from the many beautiful analogies which subsist between plants and animals. Because all animals were supposed to propagate by sexual embraces, and because plants resembled animals in their growth, their nourishment, their dissemination, and decay, it was therefore concluded, that all vegeta-

* The substance of the following facts, and reasoning, was delivered, above twenty years ago, in the Botanic Garden at Edinburgh, in presence of the late worthy and learned Dr. Hope, and his students. Dr. Hope, in order to excite industry and attention in his pupils, appointed annually four of their number to give a lecture, or discourse, upon some botanical subject, which he prescribed to them. To me the Professor assigned the Sexes of Plants, with the liberty of opposing the doctrine of Linnæus, and his own. Being at that time a very young man, and a strict believer in the sexual system of plants, I willingly undertook the task, because I thought I had the chance of showing some little ingenuity in attempting to shake a theory which I then imagined to be established upon the firmest basis of fact and experiment. But, after perusing Linnæus's works, and many other books on the subject, I was astonished to find, that this theory was supported neither by facts nor arguments, which could produce conviction even in the most prejudiced minds. This discourse was afterwards published in the first edition of the *Encyclopaedia Britannica*,

bles were either male, female, or hermaphrodite ; and that sexual commerce was equally necessary for the fecundation of the vegetable as of the animal tribes.

This analogy was plausible, and seemed to bestow a splendid uniformity on the conduct of Nature. But experiment, the only test of natural truths, has totally annihilated this beautiful fabrick. The numberless species of vine-fretters, of polypi, of millepedes, and of infusion animalcules, multiply, without having recourse to the common laws of generation. Here, then, the analogy stops ; and, instead of bringing aid to the sexualist, operates powerfully against his favourite hypothesis. If many species of animals are destitute of all the endearments of love, what should induce us to fancy that the oak or the mushroom enjoy these distinguished privileges ?

The analogy, besides, is frequently contradicted in the ordinary oeconomy of vegetables. It is universally allowed, for example, that, even in oviparous animals, the eggs can only be impregnated while they are in a gelatinous or mere embryo state. When farther advanced, their membranes, or shells, acquire a consistence sufficient to resist the male-influence. But, among the vegetable tribes, every circumstance is reversed. In most hermaphrodite plants, (I must speak in the language of the system), the seeds are not only not in a gelatinous state, but have acquired considerable bulk and solidity, long before the pollen, or supposed fecundating dust, is thrown out of its capsules.

The same remark is applicable to dioicous plants, or such as are barren and seed-bearing in different individuals. What conclusion is here to be drawn ? Analogy fails ; and facts contradict the analogy. The pollen of most plants sheds after the seeds of their respective species are far advanced in size and consistence. If this pollen had the power of fecundating, it could seldom impregnate plants of its own

species ; because, when it is discharged, the seeds are past the proper season ; but, by flying promiscuously abroad, this pollen might impregnate different species which happened then to be in a fit condition for the reception of male influence. Consider the consequences of such an arrangement. Is not this to make Nature operate against her own intentions ? Nature intends that plants should multiply and perpetuate their kinds ; but the sexual hypothesis makes her take the most effectual measures to prevent that intention, and to introduce universal anarchy among the vegetable tribes. Were this theory true, the whole vegetable kingdom, in a few years, would be utterly confounded : Instead of a regular succession of marked species, the earth would be covered with monstrous productions, which no botanist could either recognise or unravel.

The propagation of plants by suckers, slips, and cuttings, is a curious fact in the history of vegetation. The strawberry is commonly raised by slips taken from the old root, or by suckers sent off from the plant. In either of these methods, the plants flourish, and produce fruit. Many bulbous and eye-rooted plants, and most shrubs and trees, may be propagated in the same manner. Where, it may be asked, do these plants procure impregnation ? That they grow, and produce fertile fruit, is undeniable ; and yet, according to the sexual hypothesis, the pollen of the male is indispensibly necessary to the ripening and fertilization of the fruit. By means of suckers, slips, cuttings, and layers, the whole globe might be spread over with vegetables, without the possibility of a single impregnation.

Though the argument from analogy should be inconclusive, yet, say the sexualists, we appeal to facts. I shall, therefore, give a short view of the principal facts employed to support the sexual intercourse of plants.

After what has been remarked, it will not be expected that I should mention those parts of Linnaeus's reasoning which are derived from analogy. In many instances, he has pushed analogy so far beyond all decent limits, that it becomes truly ridiculous. For example, he gravely tells us, 'that the calix represents the marriage *bed*; the carolla 'the curtains; the filaments the *spermatic vessels*; the anthe- 'rae the *testes*; the pollen the *male semen*; the stigma the 'extremity of the *female organ*; the stylus the *vagina*; the 'germen the *ovarium*; the pericarpium the *impregnated ova- rium*; and the seeds the *eggs**.'

The most plausible fact in favour of the sexual hypothesis is derived from the culture of the date-bearing palm-tree. Hasselquist†, and some other travellers, mention their having seen flowering branches of male trees fixed to the females by Arabian gardeners, who alledged, that, unless this operation were performed, their dates would neither be good nor plentiful. This practice can boast of an antiquity long prior to the notion of sexes in plants. How it came to be introduced, it is of little importance to inquire. We know that the custom is still said to prevail: But we likewise know, that there is not an authentic fact which shows any connection between the *practice* and the *event*, though that be an essential ingredient in the controversy. The eastern nations are famous for introducing superstition into every part of their oeconomy; and it is equally difficult to account for their manners as for their culture of palm trees.

Mylius's letter to Dr. Watson, recorded in the Philosophical Transactions, is an attempt to remove this difficulty, and to show a necessary connection between the male and female palm. Mylius writes to his correspondent. 'That a female palm-tree grew many years in the garden belonging to the

* Sponsalia Plantarum, in Amoen. Acad. vol. 1. page 103.

† Hasselquist's Travels, page 112. 416. Kempfer. Amoen. page 706. Tournefort Ifag. page

‘ Royal Academy at Berlin, without producing any ripe or fertile fruit ; that a male branch, with its flowers in full blow, was brought from Leipsic, about twenty German miles from Berlin, and suspended over the female tree. The result was, that the female yielded, the first year, 100 ripe dates. The same experiment being repeated the following year, 2000 ripe fruit were produced.’

Not to call Mylius’s veracity in question, the experiment is both inconclusive and defective. Berlin is not the climate of palm trees. The tree, he informs us, bore flowers and fruit for thirty years before the trial was made ; but the fruit, it is said, never came to maturity. Plants seldom produce ripe fruit in a climate not adapted to their nature, until they have grown there a long time. Mylius’s palm-tree had carried unripe fruit for thirty years. According to the usual course of exotic plants, therefore, it is natural to think, that like the American aloe, the tree, during all this time, was making gradual advances toward perfection ; that, when the male branch happened to be suspended over the female, the plant had arrived at the highest degree of maturity it could ever acquire in the climate of Berlin ; and, of course, that the accidental circumstance of suspending the male branch over it, at this critical period, might give rise to the deception of attributing the ripening of the fruit to the presence of the male branch. The production of 100 ripe fruit only the first year, and 2000 the second, is a strong corroboration of this account of the matter. At any rate, the experiment is exceedingly defective and unsatisfactory. To convince any man that the fertility of this tree was solely owing to some impregnating virtue communicated to it by the male, a branch should have been suspended over the female one year, omitted the next, and so on alternately for a succession of seasons, or, as the sexualists would express it, giving her a husband one year, and denying her that gra-

tification the next. After treating the female in this manner, if it had uniformly happened, that the fruit ripened every year the male branch was suspended, and that none came to maturity when that operation was omitted, then there would have been some foundation for supposing a connection between the ripening of the fruit and the presence of the male branch. But, as this necessary precaution was omitted, the experiment is incomplete, and the conclusion drawn from it precipitate and unphilosophic.

In accounting for the fecundity of all the *dioicous** and *monoecious*† plants, the sexualists have recourse to the aid of the winds, and of insects. They betake themselves to this strange refuge, in order to explain the manner in which female plants, when situated at a distance from males, are impregnated. Some of them, as Kalm, and others, are perfectly satisfied with this supposed aerial commerce of vegetables, even when the males are ten, fifteen, or twenty miles distant from the females ! Here, it may be remarked, that the multiplication of species is one of the most important laws of Nature. All the laws of Nature are fixed, steady, and uniform, in their operation : None of their effects are abandoned to those uncertainties which necessarily result from chance, or from any fortuitous train of circumstances. But, is there any thing, in northern climates at least, more desultory and capricious than the direction and motion of the winds ? Can we form a conception of any thing more casual and uncertain than the wayward paths of insects ? The very supposition, therefore, that Nature has exposed the fertility of a tenth part of the whole vegetable kingdom, and many of them, too, plants of the utmost importance to man, and other animals, to such accidental causes, is repug-

* Plants which have the male character in one individual, and the female in another.

† Plants which have both the male and female characters in the same individual.

nant to every idea of sound philosophy. Besides, the reverse has been proved by Dr. Alston, Camerarius, and Tournefort. These gentlemen reared female plants of the spinage and hemp in such situations, and with such scrupulous precautions, to prevent any supposed impregnation by means of the wind, or of insects, that it is difficult to conceive the possibility of any communication between the males and females. These females, however, produced fertile seeds in the greatest abundance.

Since these experiments were made, it has been discovered, that male flowers are sometimes found lurking on the female plants of the spinage and hemp : And this discovery the sexualists think sufficient to account for the success of Dr. Alston's experiments. But, instead of solving the difficulty, this circumstance seems to involve it in still deeper obscurity : for, that the pollen issuing from the antherae of a male flower or two should rise, fall, and turn round in every direction, so as to light precisely on the stigmata of all the superior, inferior, and circumjacent female flowers, appears to exceed the common powers of human faith. Besides, this circumstance would seem to indicate, that there is no steadiness in what is called *vegetable sexes*. We are even told, that trees, which had continued many years under the character of females, but, from some strange metamorphosis, had suddenly dropped their female forms, and assumed the more robust features peculiar to the male part of the creation !

It was hinted above, that all the dioicous, monoecious, as well as most of the hermaphrodite flowers, being impregnated by means of the wind, seemed not to accord with the rules of philosophizing ; we shall now examine that doctrine more closely.

The pollen is allowed to be too large to get admission into the stigmata, though laid upon them with the greatest dex-

terity. This difficulty the sexualists imagine to be removed, when they tell us, that moisture makes the pollen split, and discharge a subtle aura, and that this aura impregnates the seeds. But, though the pollen should explode by the application of moisture, and discharge a subtle aura, this explosion could never effect the purposes of impregnation : For, when the pollen was lying on the stigma, the aura must necessarily blow off, instead of being absorbed by that part of the plant. Is not the supposition singular, and even contradictory, that a plant should be impregnated by a substance forcibly blown away from the female?

This reasoning proceeds upon the admission, that the pollen is laid with dexterity upon the stigma. But it will receive additional force, when I defy all the naturalists in the universe to produce an instance of a single grain of pollen being ever seen on any part of a female plant, even when at no great distance from a male, far less upon the stigmata of each separate flower. Granting, however, the pollen to be carried off from the male by the wind, yet, as the supposed fecundating aura it contains is much lighter than air, and is discharged by the slightest moisture, it can never fall down upon the distant females, but must rise and dissipate in the higher regions of the atmosphere. It may also be discharged by the application of rain or dews before the pollen is carried off by the wind from the male flowers : And, if the winds blow in a direction contrary to the situation of the female plants for a few critical hours, the females must be rendered barren, at least for a season.

It is an established fact, that coleworts, turnips, &c. when growing in gardens, sometimes produce new varieties. These varieties the sexualists uniformly hold up as instances of hybrids, or mongrels, from fortuitous commixtures of different males and females. This conclusion, however, seems to be precipitate. It is well known to nurserymen and gardeners,

that, from seeds of the same individual plants, varieties sometimes appear. If these varieties chance to have any qualities superior in value to the original plants, their seeds, shoots, or slips, are collected, and the new kind is propagated with diligence. That the beauty of flowers, and the magnitude and flavour of fruits are improveable by particular modes of culture, and even by unknown accidents, is an undeniable truth: That these improved qualities, in whatever manner procured, continue in the kind unless allowed to degenerate by negligence, is not less true. But there is nothing so wonderful in these phenomena as to require the most unbounded stretches of fancy to account for them. Are not the beauty, strength, and magnitude of animals, equally improveable by culture? Does not an ox, transported from the comparatively barren mountains of Scotland, to the rich pastures of Yorkshire, assume qualities very different from those he originally possessed? Why, then, should an inconsiderable change in the constitution of a colewort, or a turnip, excite surprise? Plants are liable to be diversified by numberless accidents. Perpetually fixed to the same local situation, they must receive, indiscriminately, such nourishment as is transmitted to them by the earth and air. When different kinds happen to grow very near each other, and, as they have not the choice of rejecting such food as is presented to them, may not exudations from the one be absorbed by the roots of the other? May not the matter which transpires so copiously from the leaves and flowers of one plant be conveyed to, and absorbed by, those of a different kind? And may not this foreign nourishment occasionally introduce some changes in the colour, texture, or flavour, of the leaves, flowers, or fruit? Nay, is it not reasonable to suppose, that solutions of various mineral substances, the action of particular manures, and a thousand other circumstances, may often induce such changes? Why, then, should we have recourse to unnatural and strained analogies?

gies, when the phenomena may be solved upon the principles of sound philosophy ?

The learned Dr. Hope, late Professor of Botany in the University of Edinburgh, who was a strenuous supporter of vegetable sexes, thought he had almost established the theory by the following experiment upon the *lychnis dioica*, of which two varieties are natives of Scotland, the one bearing white, and the other red flowers. The Doctor, about twelve years ago, raised a white female and a red male under the same glass-bell, which was sunk so far in the soil as to prevent all communication with other vegetables. The bell terminated in a tube, which, for the occasional introduction of a little fresh air, was stuffed with moss. The seeds of the white female were sown next season ; and, instead of white, the plants produced red flowers, in consequence, it was imagined, of the influence of the male upon the female. He likewise asserted, that the red kind, when left to Nature, never brought forth white flowers, nor the white kind red flowers.

Upon this experiment we have to remark, 1. That nothing is more dangerous, or more fallacious in philosophy, than the assumption of general positions without an accurate investigation. The Doctor advanced, for example, that the red and white *lychnis*, when in a natural state, never change their colours. This position is neither capable of admission nor denial ; because no experiment, nor inquiry, seems ever to have been made on the subject : Yet it is assumed as a premise to the conclusion, that the change of the white into a red *lychnis* was occasioned by the influence of the red male upon the white female.

2. That hybrids, or mules, uniformly participate of both the species or varieties by which they are engendered. A jacks ass and mare never produce a simple ass or horse, but a mule, or mixture of the two. It should seem, however, that this

red lychnis transfused its own individual qualities, without allowing a single particle of the female to appear. This is contrary to every analogy. If the change had originated from sexual commixture, the progeny ought not to have been completely red, but pied, or a mixture of red and white. To whatever cause, therefore, this change may be attributed, it can never be ascribed to any thing analogous to generation.

3. That colour is a delicate and fluctuating quality. It depends so much on light, air, health, and perhaps some unknown causes, that botanists, with great propriety, have rejected it as a specific character. Suspecting that causes of this nature might change the colour of the white lychnis under consideration, I examined the condition of some plants then subjected to the same trials in our Botanic Garden. The flowers both of the red and white lychnis were then in full blow under the bell, the glass of which was thick, and of a darker green than our common beer-bottles. The light, of course, transmitted to the plants was lurid and obscure. They were also deprived of a free circulation of air. Under these unnatural circumstances, the plants had a sickly aspect. The flowers of the red variety, instead of a vivid red, were almost perfectly white. Here we have nearly an equal change made upon the same plant, without the possibility of its being effected by the intercourse of sexes. If plants are thus deprived of proper light and air, it cannot be surprising to see changes produced in the colour of their immediate descendants. The contaminated air escaping from the plants themselves, and from the soil under the bell, may be sufficient to produce this effect. I formerly mentioned, that the colour and other qualities of plants growing near each other, may be changed by absorbing the matter of transpiration and exudation. The argument is applicable with the peculiar force to plants imprisoned so closely,

and having so little access to fresh air. In this situation, they must, of necessity, feed upon each other. Confine a man and a woman for years in a small ill-aired cell, and observe their aspect, and that of their progeny. Their appearance will be very different from that of children produced by healthy parents, and enjoying the benefit of the sun's rays, and of the open air.

4. That, independently of all these arguments, the experiment is incomplete. Even on the supposition of the existence of sexes in plants, the conclusion drawn from it cannot be admitted. The same change, for instance, might have happened, if, instead of a white female and red male, a white female had been imprisoned with a red female. In this case there could be no commixture of sexes ; and yet, it is highly probable, that both would have ripened their seeds, and that these seeds would have produced plants differently coloured from the same varieties growing in a natural state. Till these indispensable parts of the experiment, therefore, be tried, nothing can be concluded in favour of the sexual system.

5. That flowers growing from the same root, fruits upon the same tree, or raised from seeds of the same individual plant, often vary in colour, size, figure, and texture. These varieties are apparent to the most superficial observers ; but they can never, with any degree of propriety, be ascribed to the influence of sex. The causes of such variations are rather to be looked for in the exposure of the plants with regard to light and air, the nature of the soil, the mode of culture, accidental injuries from dews, from electrical fire, from the poison or wounds of insects, and from the absorption of mineral solutions. In a word, if we are to hope for an explanation of these, and other minute changes in the appearances of plants, recourse must be had to chemical and

philosophical principles, and not to an hypothetical commerce of sexes.

The discourse was concluded with the following sentiment : But I aim not at complete refutation ; for experiments are still to be made. I only wish to render the sexual commerce of plants suspicious, that the minds of men may be freed from the fetters of a system, which has, perhaps, too long received the general assent of Europe ; and that the oeconomy of the vegetable kingdom may again be open to impartial investigation.

To remove the possibility of male influence being conveyed by means of the wind, or of insects, about ten or twelve years ago, I thought, if a female plant could ripen her seeds within doors during the winter, the experiment would infallibly determine the controversy. With this view, I confined a female *lychnis*, which is a native plant of this country, and gave her such a degree of heat as made her produce flowers three months before any male flowers of the same species were blown in Britain. The flowers and the young seed had every appearance of health and vigour. But the plant itself, as usually happens to vegetables when forced to grow in unnatural situations, was feeble, slender, and double the common length it acquires in the fields. I waited the event. My expectations, however, were disappointed ; for the flowers dropped long before the seeds were ripened. The plant was kept three years in the same situation ; but still the flowers dropped, and no ripe seeds were produced. As the health of plants like that of animals, depends upon many circumstances, as exposure to the open air, to light, to the agitations of the wind, which to them answers the invigorating purpose of exercise, to nocturnal dews, to natural rains, instead of artificial waterings, &c. I resolved to place the female *lychnis* in a situation where she might enjoy all these advantages, and at the same time be removed from

every suspicion of a connection with male influence. For this purpose, I applied to my learned and ingenious friend Dr. Daniel Rutherford, now Professor of Botany in the University of Edinburgh, who, at that time, had a small garden, or rather a little area, in the heart of the city, which was surrounded with houses of five and six stories high, and distant from any male lychnis about an English mile. Dr. Rutherford received this female lychnis into his garden. The first summer after her admission, being enfeebled by her former three years confinement, she dropped her flowers, without producing fertile seeds. During three or four succeeding years, however, she remained in the same situation; and she not only ripened her seeds, but these seeds vegetated, without the possibility of any male impregnation; for the Doctor, after the young plants were in a state of discrimination, uniformly extirpated all the males, and never could discover the vestige of a single male upon the female plants. Her female progeny, however, continued to bear fertile seeds for several successive generations. If, after this, and some experiments formerly mentioned, any sexualist chooses to have recourse to the wind, and to insects, he may enjoy his theory; but few men of penetration will join him in opinion.

But, if these facts and reasonings should not be sufficient to convince every believer in the sexual system of plants that the hypothesis has no foundation in Nature, Spalanzani, a late ingenious Italian naturalist, has, by a number of experiments, removed the possibility of any rational doubt on the subject.

Spalanzani, in order to make a complete investigation of this subject, performed a number of experiments on what are called *hermaphrodite*, *monoecious* and *dioicous* plants.

Hermaphrodite plants comprehend all those which have stamens and pistils, or the male and female organs, in the same flowers. To discover whether the pollen had any in-

fluence upon the fertility of the seeds, Spalanzani forced open the petals, or flower-leaves, some time before they began to expand. He then cut off all the stamens, or male parts, before he supposed fecundating dust was ripe, leaving the female part to its fate. The result was, that, in many of the plants, the seeds did not ripen, or even acquire their full size; in others, they grew to the natural size; but after being committed to the ground, they did not germinate. Above thirty years ago, a similar set of experiments were made, in the Botanic Garden at Edinburgh, by the late Dr. Alston, the then Professor of Botany. But, whether Dr. Alston's experiments were performed with greater dexterity than those of Spalanzani, it is impossible to determine. The event, however, was the reverse; for Dr. Alston's plants, which were treated in the same manner with those of Spalanzani, not only ripened their seeds, but these seeds, when sown, were found to be as fertile as if no such operation had been performed. But no experiments of this kind can be made with any degree of certainty upon hermaphrodite plants; because they are impracticable, without wounding and injuring the tender flowers. By forcing open the petals some days before they would naturally unfold, the interior parts of the flowers are prematurely exposed to the action of the air, of dews, and of the sun's rays. Besides, no man can determine what changes the young seeds may undergo, what injury they may suffer, by an unnatural deprivation of the stamens. In every flower treated in this rough manner, an extravasation of sap must unavoidably be produced. If a pregnant animal is wounded, and in a part too so intimately connected with the foetus, what reason have we to expect a fertile and well-proportioned offspring?

Spalanzani next proceeded to trials on the monoecious plants, or those which bear both male and female flowers separately on the same individual. In spring 1777, he sow-

ed two species of the pumpon, which belong to this division of plants, in a situation removed from every suspicion of foreign connection by means of the wind or of insects. ‘In the beginning of June,’ says he, ‘two individuals, for I had ordered two only to be raised, were just beginning to put forth a few flower-buds towards the bottom of the stalk. At this early period, the male flowers may be easily distinguished from the female. The former also denominated *barren* by botanists, have a slender stalk ; while the stalk of the latter, where it joins the calyx, forms a tumor, consisting of the immature fruit. I paid daily visits to these two individuals, and very carefully watched the progress of both sorts of flowers. That there might be no suspicion of the pollen exerting any influence upon the females, the males were destroyed at their first appearance. As fruit, when a small quantity only is left upon a plant, is sooner ripe, and grows to a larger size, because it receives a greater quantity of nutritious juice, I left on each of my two individuals two flowers only. The buds that made their appearance afterwards were taken away, along with the male flowers. Meanwhile my four gourds grew rapidly. Finding that, towards the middle of September, they had attained the usual size, I gathered one, in order to inspect the internal parts. The flesh was too soft, because the fruit was not thoroughly ripe ; but, in colour, structure, and taste, it resembled fruit produced by plants which had their male flowers. The seeds were in a great number, and, as well internally as externally, were perfectly formed. At the end of the month, the other three gourds were quite ripe. I therefore gathered them, and put the seeds of each into a separate box, that I might be able to examine them at pleasure. The lobes filled the whole inside of the seeds, and had all the characters of perfect maturity.

‘Thus far,’ continues our author, ‘there is a perfect agreement with the observations made on the seeds of some hermaphrodite plants, which seemed, notwithstanding they were deprived of the efficacy of the pollen, to have acquired the same degree of perfection as those impregnated in the usual manner. But, as they did not grow, however perfect they might be in appearance, because they had not been vivified by the pollen, I imagined, that, for the same reason, the seeds of my three gourds would not grow. It was, however, proper to make the experiment. I therefore dried one hundred and fifty in the sun, and afterwards planted them in three pots, fifty in each, taken from separate gourds. But the lateness of the season, it being the 10th of October, the constant rain, and the coldness occasioned by it, circumstances unfavourable to vegetation, obliged me to place my pots in a stove, which, though it was not heated, was kept warm by a contiguous chimney. *The event did not by any means correspond to my expectation.* I took it for granted, that none of the seeds would germinate; and yet they almost all came up very well *.’

Here it is pleasant to observe candour and fair experiment triumphing over deep prejudice. From the above, and many other passages, it is evident that Spalanzani was a keen sexualist, and that he expected his experiments, instead of overthrowing, would confirm his faith; but, like a true philosopher, he candidly, though with reluctance, unhinges his favourite opinion.

‘I reserved the remainder of the seeds,’ continues Spalanzani, ‘for another experiment to be made the following spring. Before it can be asserted that fructification has been complete, it is necessary, according to the determination of botanists, not only that the seeds should grow, but that they should also be capable of bringing productive

* Spalanzani’s *Dissertations*, vol. 2. p. 276, &c.

' seeds, or, in other words, of perpetuating the species. That
' I might learn whether the seeds of my three gourds enjoy-
' ed this prerogative, caused some of them to be planted in
' the same place in May 1778 ; and, when they were grown
' to some size, they were, as in the foregoing experiment,
' carefully stripped of all their male flowers, one female
' flower only being left on each individual. These flowers
' were furnished with small gourds, which grew ripe towards
' the beginning of autumn, and the seeds they produced grew
' just as well as the former *.'

With regard to dioicous plants, or those which produce male flowers on one individual and female flowers on another, they are by far the most unexceptionable subjects for determining the existence or non-existence of sexes in plants. Accordingly, Bonnet, Fourgeroux, and Spalanzani, &c. about the year 1770, placed female plants of this description in situations so strictly guarded against the possibility of fecundating dust being conveyed to the females either by the air or by insects, that the supposition of male influence baffles all the powers of imagination. These females, however, uniformly produced ripe seeds ; and these seeds were as prolific as if they had been surrounded with males.

From the facts and arguments above related, and many others which might be adduced, it appears, that this beautiful theory, derived from a mistaken analogy, has no foundation in Nature. I would not have dwelt so long on this subject, if I had not sincerely wished that the minds of men might be emancipated from the fetters of a system which has too long received the almost universal assent of the literary world ; and that the oeconomy of the vegetable kingdom may again be open to impartial inquiries.

* Spalanzani's *Dissertations*, vol. 2 p. 278.

CHAPTER X.

Of the Puberty of Animals.

THE puberty of animals commences at that period of their existence when Nature endows them with the power of multiplying the species. This period is as various as the different tribes of animals. In some it arrives sooner, in others later; but, in every animal, it is accompanied with some remarkable changes in constitution and affections. From infancy to puberty there is a gradual increase of size; but, immediately after that period, in both sexes, the growth of the body makes a sudden spring, and acquires redoubled strength and activity. The growth of animals, however, does not always stop at the age of puberty. Men, quadrupeds, and fishes, continue to grow for some time after their capacity of multiplying. But most birds and insects seem to acquire their full dimensions before they arrive at the age of puberty.

Before puberty, the voice of a man, like that of a woman, is shrill and feeble. But, after that period, it becomes rough and strong. This effect is produced by some unaccountable and sudden change in the organs of speech, which is not confined to the human species; for the voice of a horse or a bull is deeper after than before puberty. In eunuchs, no such alteration of voice is to be observed; for their voice, though shrill and piercing, can never produce a low or deep note. At this period, too, that distinguishing characteristic of man, the beard, begins to appear, together with other external and internal changes, which it is unnecessary to relate. But eunuchs are totally destitute of beards. These two facts indicate a connection which merits the attention of philosophers.

With regard to the female sex, they are by no means exempted from constitutional changes when they arrive at the age of puberty. The alteration in the tone of their voice, if it does happen, is hardly perceptible. Neither are their faces deformed by a beard, which, according to our present ideas, would have a disgusting effect. At this period, however, their mammae swell, and a periodical evacuation takes place, which produces wonderful revolutions in their constitution and affections. In both sexes, the mental changes are not less remarkable than the corporeal. The powers of the mind expand, the force of genius is felt, and very different objects solicit attention : Instead of peurile amusements, ambition, a warm and unaffected friendship, a generosity and unsuspicious demeanour, both in words and actions, are the almost universal characteristics of this period of human life. I mention it with pleasure, that, as far as my observation extends, in youth, unless they are corrupted by example, by neglect, or by other causes, all men are honest, friendly, generous, and humane. If this remark be true, Nature is fully exculpated. But, when a young man enters into the busines of life, his candour and ingénousness soon meet with a shock. This is the painful reverse. Instead of liberality and integrity of conduct, he has to encounter with selfishness, chicane, and too often with direct villany. This unhappy discovery turns his thoughts into a different current, contracts the noble openness of his heart, renders him suspicious and guarded, and, if he shall chance to retain his integrity, he is obliged to assume, at least, the appearance of jealousy and deceit. I by no means intend this to be the universal character of mankind ; I only lament that it is too general.

In every race of mankind of which we have any knowledge, the females arrive sooner at puberty than the males. But the age of puberty differs in different countries. This

difference seems to originate from two causes, the temperature of the climate, and the quality of the food. Children of citizens, and of opulent parents, who are fed with rich and nourishing victuals, arrive sooner at this state. Children, on the contrary, brought up in the country, or whose parents are poor, require two or three years longer; because their food is not only coarse, but too sparingly given. In the southern regions of Europe, and in large cities, the females arrive at puberty about the age of twelve, and the males about fourteen. But, in northern climates, and in the country, girls hardly come to maturity till they are fourteen, and boys not before sixteen. In the warmest regions of Asia, Africa, and America, the age of puberty in females commences at ten, and sometimes at nine.

After puberty, the Count de Buffon remarks, ‘marriage is the natural state of man. A man ought to have but one wife, and a woman but one husband. This is the law of Nature; for the number of females is nearly equal to that of the males. Such laws as have been enacted in opposition to this natural principle, have originated solely from tyranny and ignorance. Reason, humanity, and justice, revolt against those odious seraglios, in which the liberty and the affections of many women are sacrificed to the brutal passion of a single man. Does this unnatural pre-eminence render those tyrants of the human race more happy? No! Surrounded with eunuchs, and with women who are useless to themselves and to other men, they are tormented with the constant appearance of that accumulated load of misery they have created.’

All animals, as well as those of the human species, undergo, at the age of puberty, similar changes in the form of their bodies, and in the dispositions of their minds. From mild, placid, and gentle, they become bold, restless, and ungovernable. Their bodies are then, in strength and symme-

try, perfectly accommodated to the new sentiments which Nature, for wise purposes, excites in their minds. In the deer kind, the horns of the males appear not till they are fit for multiplying the species. At this period, the crest, the wattles, and the plumage of the male gallinaceous birds acquire additional beauty, and their courage and strength are greatly augmented. The pigeon, instead of being querulous, timid, and voracious, whenever the age of puberty arrives, feels emotions of a very different kind. Conscious of the new vigour he has acquired, he assumes a bold and important air. He struts about with a majestic pride, and immediately addresses, with all the gaiety of a lover, some favorite female, whom he solicits with the most assiduous gallantry and attention. After the coy female gives her assent, their after conduct exhibits such a mutual and ardent affection, and such a constant fidelity, as afford no inconsiderable pattern to the human species.

With regard to fishes, we are totally ignorant of the periods when the different tribes of them acquire the power of multiplying. From the element they inhabit, from the rapidity of their motions, and from their desultory and wandering mode of living, we are equally ignorant of many other important parts of their oeconomy and manners. This continues to be an ample field for future investigation, and highly worthy of the attention of naturalists.

The oeconomy and manners of insects are more open to inspection. Those of the winged tribes undergo many changes, both in figure and structure, before they arrive at the age of puberty. They first escape from the eggs in the form of minute caterpillars. In this state they are exceedingly voracious, and grow with rapidity to their full size ; but they are destitute both of the power and of the organs necessary for the multiplication of the species. They are next formed into chrysalids : In this state, their bodies are covered

with a kind of crust or shell, from which the animals have again to escape, as from a second egg. In this imprisoned condition, they remain during a longer or shorter period, according to the species, or to the season of the year in which they are transformed. After their transformation into flies, they burst this crust or shell, and appear in the form of flies, furnished with wings, legs, feelers, &c. of all which they were destitute in their former state. When transformed into flies, caterpillars have arrived at the age of puberty. They are now perfect animals, and endowed with the faculty of transmitting a numerous progeny to posterity.

CHAPTER XI.

Of Love.

THE great intention of Nature, in endowing almost every animal with a sexual attachment, is the multiplication and continuation of the respective species. But, with regard to man, and, in an inferior degree, to all pairing animals, love is the source of many other social and important advantages. Love, or a strong affection for a particular woman, is to young men, perhaps, one of the greatest incentives to virtue and propriety of conduct. In northern countries, it seldom rises to that degree of frenzy, which, in warmer climates, not only engrosses the whole attention, but often totally unhinges the powers of the mind. In northern regions, however, it occupies more gently the imagination, gives a chearfulness and alacrity to the business or studies of life, and, if reciprocal, diffuses over the mind and body a placid happiness, and a tranquility of disposition, which greatly contribute to the health and vigour of both. A young man in love, thinks that the eyes of his favourite continually behold him. Through this amiable medium he views all his actions, and even his thoughts. His affection and veneration are so great, that he is in some measure, deterred from regarding any other woman, and, what is of more importance, from indulging any loose or irregular appetite. The dispositions and affections of the female are the same with those of the male. Her attention is completely engrossed; and she never thinks or dreams of any man, but of him who is the object of her affection. A young man and a young woman in love exhibit the most innocent and the most amiable picture of human nature. Actuated by no interested

motives, and regardless of future contingencies, they obey the supreme command of Nature. How much is it to be lamented, that, from the cruel, but perhaps unavoidable institutions and customs of civil societies, it is so often not only prudent, but necessary, to check, and even to overcome, this powerful law of Nature ?

Many are the advantages that mankind derive from society and regular governments, and we should cheerfully submit to those hardships and inconveniences to which they give rise. But every man, however submissive to the laws of his country, must regret that necessity which makes them oppose any of the laws of Nature, and especially the almost irresistible law of love.

In the present state of society, it must be acknowledged, early marriages, among people in the ordinary and dependent ranks of life, are extremely hazardous. When both parties are industrious and oeconomical, such marriages are not only the most natural, but are productive of the greatest happiness and cordiality. But the reverse is dreadful ! Children, straitened circumstances, resentment of parents, whether real or affected, too often produce all the complicated miseries to which mankind, in their lowest state of degradation, can be subjected. Among this order of men, therefore, it is of the highest importance that the law of Nature should yield, for some time at least, to the institutions of society, and to those prudential motives which parents learn from experience to be ingredients essential to the comfort and happiness of life.

Men of fortune and of opulence have it in their power to obey the laws of Nature and of love ; and some examples, though few in number, occasionally happen of rich men acting a disinterested part in their matrimonial engagements. Instead of following the dictates of Nature, many men of fortune and independence, disregarding the high privilege

they enjoy, sacrifice their taste, their passion, and often their happiness during life, at the shrine of Gold. To accomplish this Fordid end, they often embrace deformity, disease, ignorance, peevishness, and every thing that is disgusting to human nature. Let such individuals suffer their punishment. But what are the consequences to the public? Men of rank, in all nations and governments, not only regulate, in a great measure, the manners of their inferiors, but are the natural guardians of the state. For these important purposes, their minds should be noble, generous, and bold; and their bodies should be strong, masculine, fit to encounter the fatigues of war, and to repel every hostile assault that may be made upon their country. But, when men of this description, whatever be their motives, intermarry with weak, deformed, puny, or diseased females, their progeny must of necessity degenerate. The strength, beauty, and symmetry of their ancestors are, perhaps, for ever lost. What is still more to be regretted, debility of body is almost universally accompanied with weakness of mind. Thus, by the avarice, ambition, or inattention, of one individual, a noble and generous race is completely destroyed. By reversing this conduct, it is true, the breed may again be mended; but, to repair a single breach, many generations, endowed with prudence and circumspection, will be requisite. A successive degeneration, however, is an infallible consequence of imprudent or interested marriages of this kind. One puny race may for some time be succeeded by another, till at last their constitutions become so feeble that the animals lose the faculty of multiplying their species. This gradual degeneration is one great cause of the total extinction of conspicuous and noble families. That it should be so, is a wise and beneficent institution of Nature; for, if such debilitated races were continued, a universal degeneration would soon take place, and mankind would be unable to perform the duties, or to under-

go the labours of life. Nature first chastises, and at last extirpates, all those who act contrary to her established laws.

Beside the pleasures resulting from society, and from mutual attachment in man, and in pairing animals, the natural love of offspring is a source of the most engaging endearments. The innocence and helpless condition of infants call forth our pity and protection. When a little farther advanced, their beauty, their smiles, and their sprightliness, excite the most agreeable emotions. In their progress from infancy to manhood, we observe with pleasure the unfolding of their mental powers. They imitate our actions long before they can express their desires, or their wants, by language. Their attempts in the acquisition of language are extremely curious and amusing. Their first system of grammar consists entirely of substantive nouns. It is long before they learn the use of adjectives or of copulatives, and still longer before they employ the verb. Their speeches are short, awkward, and blundering; but they are animated, and uttered with astonishing force and vivacity of expression in their eyes, and in the gestures of their bodies. At this period of life, children are solely actuated by Nature and imitation. After they acquire words sufficient for conveying the few ideas they possess, they begin to reason, or rather to employ the language of reasoning; for, at this period of life, children, when they mean to give a reason why they should have any indulgence or gratification, almost universally argue against themselves, and employ a reason why their desires should not be granted. This ridiculous mode of reasoning excites laughter, and affords pleasure and amusement to the parents. It likewise shows, that our first attempt toward reasoning is principally, if not solely, the effect of imitation; for the reasoning power, at this period, is not fully unfolded, because many human instincts, or mental qualities, have not yet been called forth into action. But

here I must stop. To do justice to this interesting subject would require volumes.

The love of offspring, which, though not universal, is perhaps the strongest and most active principle in human nature. It overcomes the sense of pain, and sometimes even the principle of self-preservation. A remarkable and a melancholy example of the strength of parental affection was lately exhibited, and, for the honour of our species, deserves to be recorded. In the beginning of January 1786, the Halfewell East Indiaman, Captain Richard Peirce, was unfortunately wrecked on the coast of Dorsetshire. Beside several other ladies, Captain Peirce had two of his own daughters on board. When the ship was in the extremity of danger, some of the company, by swimming, and other feats of activity, got upon a rock. In this dreadful situation, Captain Peirce asked Mr. Rogers, his third mate, if any plan could be devised for saving the ladies ? Mr. Rogers replied, ‘It is impossible ! but you may save yourself.’ Upon which the Captain, addressing himself to his daughters, and enfolding them in his arms, said, ‘Then, my dear children, ‘we shall not part ; we shall perish together !’ Mr. Rogers quitted the ship and reached the rock : An universal shriek of despair was heard, in which the voices of female distress and horror were lamentably distinguishable. In a few moments all was hushed ; the ship, with every person on board, had then gone to the bottom. Parents cheerfully submit to the hardest labour, and expose themselves to the greatest dangers in order to procure nourishment to their young, or to protect them from injury.

A bitch, during the operation of dissection, licked her young, whose presence seemed to make her forget the most excruciating tortures ; and, when they were removed, she uttered the most dolorous cries. Certain species of spiders inclose their eggs in a filken bag spun and wove by them-

elves. This bag they fix to their back, and carry it along with them wherever they go. They are extremely nimble in their motions. But, when the bag is forced from a spider of this kind, her natural agility forsakes her, and she falls into a languid state. When the bag is again presented to her, she instantly seizes it, and carries it off with rapidity. The young spiders no sooner escape from the eggs than they dexterously arrange themselves on the back of the mother, who continues for some time to carry them about with her, and to supply all their wants. Another species of spider attaches her bag of eggs to her belly. This spider is likewise very agile, and so ferocious and determined in the protection of her eggs, that she has been known to suffer death rather than relinquish them. The deer spontaneously presents herself to be chased by the dogs, to prevent them from attacking her fawn. When the fox perceives that her young have been disturbed in her absence, she carries them off, one after another, and conceals them in a new retreat. Wasps feed their young, when in the worm or caterpillar state, in the same manner as pigeons and other birds that disgorged. The pigeon, after swallowing grain, retains it for some time in her stomach, till it is softened and macerated : She then disgorges, and throws it into the mouths of her young. ‘ In the same manner,’ says Reaumur, ‘ I have observed a female wasp swallow a large portion of an insect : In a short time afterwards, she traversed the different cells of her nest, disgorged the contents of her stomach, and distributed food in this half digested form to her young worms*.’

All animals, man perhaps not excepted, acquire a double portion of force and courage after they bring forth. A cow, at least in a domestic state, is a placid and phlegmatic animal : But, whenever she produces a calf, a wonderful change is exhibited : She instantly becomes vigilant, active,

* Reaumur, tom. II. page 230. 12mo. edit.

and even ferocious, in the defence of her young. A lioness deprived of her cubs presents the most dreadful picture of anxiety, rage, and rapacity. Descending lower in the scale of animation, the same change is to be remarked. A domestic hen is a timid, indocile, and obstinately stupid creature. Though chaced, harassed, and even put in danger of her life, fifty times in a day, she never learns to avoid a garden, or any particular place which she is accustomed to frequent, or to which she is led by her appetite for food. But, the moment her chickens are hatched, instead of her usual timidity, she becomes as bold as a lion. When she thinks her young are in danger, she bristles up her feathers, assumes a fierceness in her eye, makes an alarming noise, and attacks, in the most furious manner, and without distinction, every animal that comes near her. By the suddenness of her onsets, she often alarms men, and actually intimidates and beats off dogs and other animals that could devour her in an instant.

Though several of the insect tribes discover a strong attachment to their young, yet all those which undergo transformations, and do not form societies, must be completely ignorant of the existence of their progeny ; because, in general, the parents die before the young are hatched. Nature, however, has endowed those species with an instinct which produces all the effects of parental affection : They uniformly deposit their eggs in substances which afford to the young, immediately after their escape from the egg, a nourishment adapted to their respective constitutions, and a comfortable and safe protection from injury. Thus nature, ever attentive to the continuation and happiness of her productions, however seemingly insignificant in the scale of being, often employs very different means to accomplish the same beneficent purposes.

Nature has unquestionably attached pleasure to all the necessary functions of animals. But this pleasure cannot be

considered as the original cause of any particular action ; for the experiment must be made before the animal can discover whether the result is to be agreeable or disagreeable. The truth is, that Nature has bestowed on the minds of all animated creatures a number of laws or instincts perfectly accommodated to the species, and which irresistibly compel them to perform certain actions. The effects of these laws we perceive : But the causes, or the modes by which they operate on animal minds, are inscrutable. We may and must admire, but we can never penetrate the mysteries of Nature.

Bonnet, and some other naturalists, imagine they are exhibiting the causes of that strong and mutual attachment between parents and their offspring, when they tell us, that, in man, and quadrupeds, and birds, the mother is fond of her young, because their natural actions give rise to agreeable sensations ; that, from the structure of the mammae, a gentle, but pleasant sensation, is excited by the action of sucking ; that the mother is often incommoded by too great a quantity of milk, and that sucking relieves her ; that the young love their mother, because she feeds, protects, and communicates to them a cherishing warmth ; that, among the feathered tribes, and particularly those which sit upon their young, by the gentle motions of the little ones, an agreeable sensation is excited in the belly of the mother, which is then frequently deprived of feathers. All these sources of reciprocal pleasure may be true : But still they are only effects, and not original causes, of filial and parental affection ; for that mutual attachment exists the moment after the young animals come into the world, and, of course, previous to all experience of titillation, of heat, of habit, or of any other circumstances that may, perhaps, contribute to strengthen or prolong the exertion of the primary cause, which must remain forever concealed from human penetration.

In most animals, except the human species, parental and filial affection cease whenever the young are able to provide for themselves. The pleasures derived from sucking, and from other circumstances formerly mentioned, might for some time remain ; but the young grow large, unwieldy, petulant, and enter into competitions for food, which not only contribute to alienate the affection of the parents, but even to excite resentment and aversion. These, however, are only secondary causes. The purposes of Nature are fulfilled. The ardour of affection, which was indispensably necessary to the protection and rearing of the young, being now no longer useful, is so totally extinguished, that neither the parents nor the offspring are capable of recognizing one another. This temporary and amiable instinct is obliterated, and never revives till the fervours of love are again felt, and a new progeny appear.

Marriage or pairing, though by no means an universal institution of Nature, is not unfrequently exhibited in the animal creation. With regard to man, both male and female are instinctively impelled to make a selection. The force of this natural impulse is strongly felt by every young and uncorrupted individual. When not restrained by necessity, or other powerful motives, men and women would intermarry long before it would be prudent in civilized or artificial states of society. This universal, and almost irresistible impulse of selection, is to me the strongest argument in favour of monogamy, or the union of pairs, among the human species.

The same impulse, or law of Nature, takes place among many other animals, as the partridge tribes, the swallow, the linnet, and, in general, all the small birds. The assiduity, attention, mutual affection, laborious vigilance, and steadfast fidelity of pairing animals, are truly admirable, and to inge-

nious minds, afford the most exemplary admonitions to virtue and conjugal attachment.

Beside this forcible impulse of selection implanted by Nature in man, and in every other pairing animal, some other facts deserve to be noticed. In all pairing animals, including, of course, the human race, the males and females produced are nearly equal. This is a plain indication that Nature destined these animals to pair, or to marry. Injustice, jealousy, animosity, and every animal calamity, would ensue, if this order of Nature were encroached upon in creatures who are endowed with the instinct of sexual selection.

It is not incurious to remark, that human institutions often contradict the laws of Nature. The dunghill cock and hen, in a natural state, pair. In a domestic state, however, the cock is a jealous tyrant, and the hen a prostitute. But, even in this unnatural society, a selection is sometimes to be observed. The same phenomenon is exhibited among mankind, when placed in certain situations. Like domestic poultry, the Turks, and some Asiatic and African nations, influenced by an accursed government, and by an execrable religion, rebel against the law of love, and of reciprocal attachment. In these countries, a rich man not only engrosses, but imprisons and tortures, as many beautiful women as his fortune enables him to support. Destitute of all those endearments which arise from mental communication, from parental tenderness and affection, from mutual confidence and solace, he is, while young, perpetually tormented with jealous apprehensions. As he advances in life, his jealousy and his terror augment. Though his females are scrupulously guarded from every intrusion, by servile and mutilated wretches, his fears increase with his years and debility, till a premature and comfortless old age puts a period to his insignificant and listless existence.

In general, it is to be remarked, that all those species of animals, whose offspring require, for some time, the industry and

support of both parents, are endowed with the instinct of selection, or of pairing. With regard to the feathered tribes, pairing is almost universal. A distinction, however, as to the duration and circumstances of their pairing is to be observed. The young of all the small birds, as well as of most of the larger kinds, continue for some weeks in a weak and helpless condition. The mother is not, like quadrupeds, provided with organs fitted to secrete milk ; of course, she is unable to nourish them out of her own body. She is therefore obliged to go abroad in quest of food for them. But the progeny are so numerous, that all her industry, if not assisted by the father, would be ineffectual for their support and protection. In all birds whose young are in this condition, the males and females not only pair, but each of them is endowed with the strongest parental affection. Both are equally anxious and industrious in procuring food for their mutual offspring. This parental care and attachment uniformly continues till the young are fledged, and have acquired sufficient strength to provide for themselves. Eagles, and some other birds of prey, continue faithfully in pairs for years, and perhaps during life. These facts afford a strong argument in favour of marriage among mankind. No animal remains so long in the infant and helpless state as the children of men ; and no mother could, with her own industry, possibly suckle and procure nourishment for a numerous family. Here, as in the feathered tribes, the assistance of the father becomes indispensable. On this subject, a curious instinct merits attention. The male of most birds not only selects a female, but, with great assiduity, brings food to her when sitting on her eggs, and often relieves her, by sitting on them himself.

There are other species of pairing birds, whose young, as soon as they are hatched, are capable of eating their food when presented to them, and of course, require less labour

from the parents. In these species, accordingly, the male pays no attention to the progeny, because it is unnecessary ; but the mother carefully leads them about to places where proper food is to be had, protects them from injuries, and communicates heat to them by covering them with her wings.

Quadrupeds, especially those which feed upon grass, do not pair ; because, while the female gives suck to her young, she herself is feeding. Beside, the young of this tribe, very soon after birth, can eat grass and other vegetables. The Count de Buffon remarks, that the roe-deer, though they feed upon grass, are to be excepted from this rule ; for they pair and have annually but one litter. Lions, tigers, wolves, and other rapacious quadrupeds, do not pair. The whole labour of procuring food is devolved upon the female, which often shortens her own life, as well as that of her offspring. In relation to man, this is a fortunate circumstance, for, if beasts of prey paired, a dangerous multiplication of those destructive species would be the consequence. But pairing is essentially necessary to birds of prey ; because, during the process of incubation, the female would not have time sufficient for procuring food ; which, in these animals, requires both patience and address. Some quadrupeds, particularly those which lay up provisions for the winter, as the beaver, pair. As soon as the young beavers are produced, the males abandon the stock of provisions to the females, and go in quest of food for themselves. But they by no means relinquish their mates ; but frequently return and visit them while they are suckling their young.

If man, and some of the pairing animals be excepted, the seasons of love are limited to particular times of the year. These seasons, though various, are admirably adapted to the nature and oeconomy of the different species. In all animals of this kind, the seasons of love, and the times of fe-

male gestation, are so contrived by Nature, that the offspring when brought forth, are amply supplied with the particular species of food upon which they principally live. Though the times of gestation vary considerably among such quadrupeds as feed upon grass, the respective females uniformly bring forth early in summer, when the grass is tender and luxuriant. The mare comes in season in summer, carries eleven months, and is delivered in the beginning of May. Sheep and goats come in season in the end of October or beginning of November. They carry five months, and produce when the grass begins to spring. It is worthy of observation, that, though the times of gestation in the same species, and in all latitudes, never alter, yet the seasons of love, and times of delivery, vary with the climate. In Italy, sheep come in season in the months of June or July. The females, as usual, carry five months, and bring forth in November or December, the very period when grass, in that climate, is in its best state for pasture; for, in April, it is burnt up, and sheep have nothing to browse upon but shrubs. The rutting season of the stag is in the end of September and beginning of October, and the female brings forth in May or the beginning of June. These animals inhabit the highest mountains of Scotland, where the grass, of course, does not begin to spring so early as in the lower parts of that country. Beavers come in season about the end of autumn, and bring forth in January, when their store-houses are full of provisions. The young of pairing birds are produced in the spring, when the weather begins to be comfortably warm, and their natural food abounds. In a word, the bringing forth, or hatching, of all animals, not excluding the insect tribes, uniformly takes place at those seasons of the year when the nature of the weather, and the food peculiar to the species, are best adapted to the constitution of their offspring. Caterpillars of every kind are never hatched till

the various plants on which they feed though they grow in different months, have put forth their leaves.

We shall conclude this subject, by giving a Table of the Relative Fecundity, &c. of Animals, which, in a short compass, solves a number of questions with regard to the natural history of quadrupeds. It is taken from the eighth volume of the Translation of Buffon, to whose authority most readers will be inclined to give great weight.

TABLE OF THE RELATIVE FECUNDITY OF ANIMALS.

NAMES.	Age at which Males can engender, and Females produce. MALE. Years.	Times of gestation, FEMALE. Years.	Numb of young produced at a litter. MALE, Years.	Age at which Males cease to engender, and Females to produce. FEMALE. Years.
Elephant -	30	-	-	-
Rhinoceros	15 or 20	-	-	-
Hippopotamus	-	-	-	-
Walrus -	-	-	-	-
Camel -	4	-	4	9 months
Dromedary	4	-	4	1 year nearly idem
Horse -	2½	-	2	11 months
Zebra -	2	-	2	11 ditto.
Afs -	2	-	2	11 do, and more
Buffalo -	3	-	3	9 months
Ox -	2	-	1½	9 ditto.
Stag	1½	-	1½	8 do, and more
Rain-deer	2	-	2	8 months
Lama	3	-	3	9 mouths
Man -	14	-	12	5 ditto,
Large Apes	3	-	3	-
Mousson -	1½	-	1	-
Saiga -	-	-	1	5 ditto.
Roebuck -	-	-	2	5 ditto,
Chamois Goat	-	-	1	5 ditto.
Goat -	-	-	7 months	5 ditto.
Sheep -	-	-	1	5 ditto,

NAMES.	Age at which Males can engender, and Females produce.		Times of gesta- tion.	Numb. of young produced at a litter.	Age at which Males cease to engen- der, and Females to produce.
	MALE. Years.	FEMALE. Years.			
Seal	-	2	several months ditto.	2 or 3 1, 2, 3, 4, and never above 5	lives 20 or 25
Bear	-	2	-	3 or 4	lives 20 or 25
Badger	-	2	-	3 or 4	once a year
Lion	-	2	-	4 or 5 once a year	at 15 or 20
Leopard & Tiger	2	-	73 days or more	5, 6, to 9, once a year	at 15 or 20
Wolf	2	-	9 or 10 months	3, 4, 5, 6	at 15 -
Dog in a natural state	-	9 or 10 months	63 days	6 and 7	at 10 or 11
Havis	-	1	-	3, 4, to 6	at 10 or 11
Fox	-	1	-	-	at 9 -
Jackal	-	-	before 1	2, 3, or 4 4, 5, or 6	at 9 -
Cat in a natural state	1	-	-	56 days	at 9 -
Martin	1	-	-	3, 4, and 6	at 8 or 10
Pine Weasel	1	-	-	3, 4, and 6	at 8 or 10
Polecat	1	-	-	idem	gener, during life
Weasel	-	1st year	-	3, 4, and 5	prod. during life
Ermine	-	idem	-	3, 4, and 5	idem
Squirrel	1	-	-	copulates in March and produces in May	idem -
					3 or 4

Flying Squirrel

NAME.	Age at which Males can engender, and Females produce.		Times of gestation.	Numb. of young produced at a litter.	Age at which Males cease to engender, and Females to produce.
	MALE. Years.	FEMALE. Years.			
Hedgehog	-	1st year	-	40 days	3, 4, and 5
Dormice	-	1st year	-	-	3, 4, and 5
Musk Rats	-	-	-	-	4, 5, or 6
Opossums	-	-	-	-	4, 5, 6, and 7
Hogs	-	1 year or 9 mos.	1 year or .9 mos.	4 months	10, 12, 15, to at 15
Armadillos	-	-	-	-	20, twice a year
Hare	-	1st year	1st year	-	4 several times a year
Rabbit	-	5 or 6 months	5 or 6 months	30 or 31 days	2, 3, 4, several times a year
Ferret	-	1st year	1st year	idem	4, 5, to 8, fever- al times a year
Rats	idem	-	idem	40 days	5, 6, to 9, twice a year
Field Mice	idem	-	idem	5 or 6 weeks	.5 or 6 several times a year
Mouse	idem	-	idem	1 month, or .5 weeks	.9 or 10 several times a year
Brown Rat	idem	-	idem	idem	.5 or 6 several times a year
Guinea Pig	5 or 6 weeks	-	5 or 6 weeks	12 to 19 thrice a year	1 to 19 thrice a year
			3 weeks	-	8 times a year;
					1st litter, 4 or 5;
					2d, 5 or 6; and
					the others, 7, 8, to 11
					lives 6 or 7, and produces during life

CHAPTER XII.

Of the Transformation of Animals.

THE transformation of caterpillars, and of different kinds of worms, into winged insects, has long excited the attention, as well as the admiration of mankind. But the truth is, that every animal, without exception, undergoes changes in structure, mode of existence, and external appearances. Mankind, from their embryo state, to their final dissolution, assume many different forms. Some weeks after conception, the rudiments of a human being are to be perceived. As pregnancy advances, the approaches to the perfect figure become gradually more distinguishable, till the period of birth. While in the foetus state, the head is disproportionately large, when compared with the other parts of the body ; nourishment is conveyed to it by very different channels ; and respiration is not necessary, because the circulation of the blood is not carried on in the same manner as after birth. Even after birth, the form, symmetry, and organs of the animal are by no means complete. The head continues for some time to be disproportionately large ; the hands and feet are not properly shaped ; the legs are crooked ; the hair on the head is short and scanty ; no teeth as yet appear ; and there is not a vestige of a beard. In a few months, however, the symmetry of all the parts is evidently improved, and the teeth begin to shoot. The growth of the whole body, as well as the strength and beauty of its form gradually advance to perfection till the sixth or seventh year, when another change takes place. At this period, the first set of teeth are shed, and are replaced by new ones. From boyhood to puberty, the size of the body, and of its different members, increase. When the age of puberty arrives,

several important changes are produced in the system of both males and females. The beard now makes its appearance ; the dimensions of the body, in most individuals, are suddenly augmented ; and both sexes become capable of multiplying the species. From this period, to the age of twenty-five or thirty, the muscles swell, their interstices are filled with fat, the parts bear a proper proportion to each other, and man may now be considered as a perfect animal. In this state of bodily perfection and vigour, he generally remains till he reaches his fiftieth year. Then a new but a gradual change begins to appear. From the fiftieth year to the age of seventy or eighty, the powers of the body decline in their strength and activity. The muscles lose their spring and their force. The vigour of manhood is no longer felt ; and the withered decrepitude of old age is succeeded by death, its unavoidable consequence.

The mind of man undergoes changes as well as his body. The taste, the appetites, and the dispositions, are in perpetual fluctuation. How different is the taste of a child from that of a man ? Fond of gewgaws and of trifling amusements, children frolic away their time without much thought or reflection. When advancing toward puberty, their dispositions and desires suffer a gradual mutation. New instincts are unfolded, and a sense of propriety begins to be perceived. They despise their former occupations and amusements ; and different species of objects solicit and obtain their attention. Their powers of reflection are now considerably augmented ; and both sexes acquire a modesty and a shyness with regard to each other. This awkward, but natural bashfulness, by the intercourse of society, as well as by the impulses of Nature, vanishes soon after puberty, when the state of manhood and of gallantry commences. From this period, to the age of twenty-five or thirty, men's minds assume a bold, enterprising, and active tone. They engage in the

business of life, look forward to futurity, and have a desire of marrying and of establishing families. All the social appetites are in vigour ; solid and manly friendships are formed ; and man goes on for some time to enjoy every kind of happiness which his nature is capable of affording. I wish the next change had no existence. At fifty or sixty, the mental powers, in general, like those of the body, begin to decline, till feeble and tremulous old age arrives, and death closes the mutable scene of human life.

With regard to *quadrupeds*, both before and after birth, they undergo similar, and many of them greater, changes of form than those of the human species. Their mental powers, likewise, their dispositions and manners, as well as the objects of their attention, vary according to the different stages of their existence. Many of them come into the world blind, and continue for some time before they receive the sense of seeing. How many changes are exhibited in the dog from birth till all his members are completely formed, and all his instincts are unfolded and improved by experience and education ? The deer-kind acquire not their magnificent and beautiful horns before the age of puberty ; and even these are annually cast off and renewed. Similar changes take place in quadrupeds of every denomination ; with examples of which every man's experience and recollection will readily supply him ; and, therefore, it is unnecessary to be more particular.

Neither are *Birds*, in their progress from birth to maturity, exempted from changes. Like quadrupeds, many birds are blind for some time after they are hatched. In this condition, how different are their form and appearances from those of the perfect animals ! At first, they are covered with a kind of down instead of feathers. Even after the feathers shoot, they are often of a colour different from that which they acquire when full grown. The beautifully variegated

colours of the peacock's tail appear not till he arrives at his third year *. Birds that have crests, or wattles, live a considerable time before they acquire these ornaments, or marks of distinction. All birds annually molt, or cast their feathers, in the same manner as quadrupeds shed their hair, the new pushing out the old.

Frogs, and many other *amphibious* animals, undergo great changes in their form and structure. When it first escapes from the egg, a frog appears in the form of a tadpole, an animal with a large roundish head, and a compressed or flat tail, but totally destitute of feet and legs. In this state it remains a considerable time, when the two fore-feet begin to shoot, and have an exact resemblance to the buds of trees. As their growth advances, the toes and legs are distinguishable. The same process goes on with the hind-legs, only they are somewhat later in making their appearance. During the growth of the legs, the blood being drawn into different channels, the tail suffers a gradual mortification, till at last it totally vanishes, and the tadpole is metamorphosed into a quadruped. Tadpoles never come out of the water; but, after their transformation into frogs, they become amphibious, and occasionally frequent both land and water.

The *crustaceous* tribes, as lobsters, crabs, &c. beside the different appearances they assume while growing to perfection, cast their shells every year. When this change is about to happen, they retire into the crevices of rocks, or shelter themselves below detached stones, with a view to conceal and defend their bodies from the rapacious attacks of other fishes. After the shells are cast, the animals are exceedingly weak and defenceless. Instead of their natural defence of hard shells and strong claws, they are covered only with a thin membrane or skin. In this state they become an easy prey to almost every fish that swims. The skin, however,

* Linnæi Amoen. Acad, vol. 4. p. 368.

gradually thickens and grows harder, till it acquires the usual degree of firmness. By this time the animals have resumed their former strength and activity; they come out from their retirements, and go about in quest of food.

Serpents, and many other *reptiles*, cast their skins annually. The beauty and lustre of their colours are then highly augmented. Before casting, the old skins have a tarnished and withered appearance. The old skins, like the first set of teeth in children, are forced off by the growth of the new.

We come now to give some account of the transformations of *insects*, which are both various and wonderful. All winged insects, without exception, and many of those which are destitute of wings, must pass through several changes before the animals arrive at the perfection of their natures. The appearance, the structure, and the organs of a caterpillar, of a chrysalis, and of a fly, are so different, that, to a person unacquainted with their transformations, an identical animal would be considered as three distinct species. Without the aid of experience, who could believe that a butterfly, adorned with four beautiful wings, furnished with a long spiral proboscis or tongue, instead of a mouth, and with six legs, should have proceeded from a disgusting, hairy caterpillar, provided with jaws and teeth, and fourteen feet? Without experience, who could imagine that a long, white, smooth, soft worm, hid under the earth, should be transformed into a black, crustaceous beetle, having wings covered with horny elytra, or cases?

Upon this branch of the subject, we shall, *first*, give an example or two of the most common transformations of Insects; and, *secondly*, describe some of the more uncommon kinds.

Beside their final metamorphosis into flies, caterpillars undergo several intermediate changes. All caterpillars cast or

change their skins oftener or more seldom, according to the species. Malpighius informs us, that the silk-worm, previous to its chrysalis state, casts its skin four times. The first skin is cast on the 10th, 11th, or 12th day, according to the nature of the season ; the second in five or six days after ; the third in five or six days more ; and the fourth and last in six or seven days after the third. This changing of skin is not only common to all caterpillars, but to every insect whatever. Not one of them arrives at perfection without casting its skin at least once or twice. The skin, after it is cast, preserves so entirely the figure of the caterpillar in its head, teeth, legs, colour, hair, &c. that it is often mistaken for the animal itself. A day or two before this change happens, caterpillars take no food : They lose their former activity, attach themselves to a particular place, and bend their bodies in various directions, till at last they escape from the old skin, and leave it behind them. The intestinal canal of caterpillars is composed of two principal tubes, the one inserted into the other. The external tube is compact and fleshy ; but the internal one is thin and transparent. Some days before caterpillars change into the chrysalis state, they void, along with their excrement, the inner tube which lined their stomach and intestines. When about to pass into the chrysalis state, which is a state of imbecility, caterpillars select the most proper places and modes of concealing themselves from their enemies. Some, as the silk-worm, and many others, spin filken webs or cords round their bodies, which completely disguise the animal form. Others leave the plants upon which they formerly fed and hide themselves in the little cells which they make in the earth. The rat-tailed worm abandons the water upon the approach of its metamorphosis, retires under the earth, where it is changed into a chrysalis, and, after a certain time, bursts

from its seemingly inanimate condition, and appears in the form of a winged insect. Thus the same animals pass the first and longest period of their existence in the water, another under the earth, and the third and last in the air. Some caterpillars, when about to change into a chrysalis state, cover their bodies with a mixture of earth and silk, and conceal themselves in the loose soil. Others incrust themselves with a silky or glutinous matter, which they push out from their mouths, without spinning it into threads. Others retire into the holes of walls or of decayed trees. Others suspend themselves to the twigs of trees, or to other elevated bodies, with their heads undermost. Some attach themselves to walls, with their heads higher than their bodies, but in various inclinations; and others choose a horizontal position. Some fix themselves by a gluten, and spin a rope round their middle to prevent them from falling. Those which feed upon trees attach themselves to the branches, instead of the leaves, which are less durable, and subject to a greater variety of accidents. The colours of the caterpillars give no idea of those of the future flies.

In general, the figure of chrysalids approaches to that of a cone, especially in their posterior part. When under this form, the insect seems to have neither legs nor wings. It is incapable either of walking or of crawling. It takes no nourishment, because it has no organs suited to that purpose; yet, in some species, life is continued for several months before their last metamorphosis takes place. In a word, it seems to be a lifeless mass. But, upon a more attentive observation, it possesses the power of bending upwards and downwards the posterior part of its body. The skin, or exterior covering, of those which do not spin cords, seems to be of a cartilaginous nature. It is commonly smooth and shining. In some species, however, the skin of the chrysalis is more or less covered with hair, and other rugosities. Though

chrysalids differ both in figure and colour, their appearances are by no means so various as those of the caterpillars from which they are produced. The colour of some chrysalids is that of pure gold, from which circumstance the whole have received their denomination. For the same reason they are called *aureliae* in Latin. Some are brown, others green ; and, indeed, they are to be found of almost every colour and shade.

The life of winged insects consists of three principal periods, which present very different scenes to the student of Nature. In the first period, the insect appears under the form of a *worm* or *caterpillar*. Its body is long, cylindrical, and consists of a succession of rings, which are generally membranous, and encaised within each other. By the aid of its rings, or of crotchets, or of several pairs of legs, it crawls about in quest of food ; and its movements are, in some species, remarkably quick. Its head is armed with teeth, or pincers, by which it eats the leaves of plants or other kinds of food. In this state, it is absolutely deprived of sex, and, consequently, of the power of multiplication. Its blood moves from the tail toward the head. It respires either by stigmata or small apertures placed on each side of its body, or by one or several tubes situated on its posterior part, which have the resemblance of so many tails. In the second period, the insect appears under the form of a *nymph*, or that of a *chrysalis*. When an insect, after throwing off the skin of the caterpillar, exhibits all its external parts, only covered with soft and transparent membranes, it is called a *nymph*. But, when to these membranes is added a common and crustaceous covering, it receives the name of a *chrysalis*. While in the state of a *nymph*, or that of a *chrysalis*, insects, in general, are totally inactive, and seem not to possess any powers of life. Sunk into a kind of deep sleep, they are little affected with external objects. They can make no use of their eyes,

their mouth, or any of their members ; for they are all imprisoned by coverings more or less strong. No cares occupy their attention. Deprived of the faculty of motion, they remain fixed in those situations which they have chosen for their temporary abode, or where chance has placed them, till their final metamorphosis into flies. Some of them, however, are capable of changing place ; but their movements are slow and painful. Their blood circulates, but in a contrary direction from what takes place in the caterpillar state ; for it proceeds from the head toward the tail. Respiration continues to go on, but the organs are differently situated. In the caterpillar, the principal organs of respiration were placed at the posterior part of the body ; but now these same organs are to be found at the anterior part of the animal. In the third period, the insect has acquired that perfect organization which corresponds to the rank it is to hold in the scale of animation. The bonds of the nymph, or of the chrysalis, are now burst asunder, and the insect commences a new mode of existence. All its members, formerly soft, inactive, and folded up in an envelope, are expanded, strengthened, and exposed to observation. Under the form of a worm or caterpillar, it crawled ; under those of a nymph, or chrysalis, its power of motion was almost annihilated ; under the last form, it is furnished with six springy legs, and two or four wings with which it is enabled to fly through the air. Instead of teeth or pincers, with which it divided a gross aliment, it has now a trunk by which it extracts the refined juices of the most delicate flowers. Instead of a few smooth eyes which it possessed in the worm or caterpillar state, the new insect is furnished with both smooth and convex eyes, to the number of several thousands.

The internal parts of the insect have likewise undergone as many changes as the external. The texture, the proportions, and the number of the viscera, are greatly altered.

Some have acquired an additional degree of consistence; others, on the contrary, are rendered finer and more delicate. Some receive a new form, and others are entirely annihilated. Lastly, some organs in the perfect insect, which seemed formerly to have no existence, are unfolded, and become visible. The most important of this last kind are the organs of generation. The caterpillar, the nymph, and the chrysalis, were of no sex. But, after transformation, both sexes are distinguishable, and the animals are capable of multiplying their species.

We shall now give some examples of transformations which deviate from the common mode.

Some insects hold a middle rank between those which preserve their original figure during life, and those that suffer transformations. Their existence is divided into two periods only. They walk in the first, and fly in the second. Thus their only metamorphosis consists of the addition of wings, the growth and expansion of which are performed without any considerable alteration in the figure of their bodies.

There is not a law established among organized bodies which seems to be so universal, as that all of them grow, or augment in size, after birth, till they arrive at maturity. If a hen were to bring forth an egg as large as her own body, and if this egg, when hatched, were to produce a bird of equal dimensions with either of the parents, it would be considered as a miracle. But the *spider-fly*, so denominated from its figure, affords an example of a similar prodigy. This fly actually lays an egg, from which a new fly is hatched that is as large and as perfect as its mother. This egg is roundish, is at first white, and afterwards assumes a shining black colour. Upon a more accurate examination, however, this production was found to be an egg only in appearance. When the envelope is removed, instead of a gelatinous sub-

stance, the new insect, furnished with all its members, is discovered. But this discovery does not render the fact the less wonderful. All winged insects undergo their different transformations after being expelled from the bodies of their mothers, and receive great augmentations of size before their metamorphosis into the nymph or chrysalis state, after which their growth stops. But the spider-fly affords an instance of an insect transformed in the belly of its mother, and which grows no more after it escapes from its envelope. This fact is fully authenticated by Reaumur*, Bonnet†, and other naturalists.

The worm from which the tipula or crane-fly is produced is perfectly smooth. Immediately before its first transformation it retires under ground. After this metamorphosis, the surface of the nymph is furnished with a number of prickles. By means of these prickles, the nymph, when about to be transformed into a fly, raises itself in its hole till the chest of the insect is above ground. The fly then bursts its prison, mounts into the air, and leaves its former covering behind in the earth.

Many species of flies deposit their eggs in the leaves and different parts of plants. Soon after the egg is inserted into the leaf, a small tubercle begins to appear, which gradually increases in magnitude till the animal is hatched, and has passed through its different transformations. These tubercles are known by the name of galls, and are very different in their form, texture, colour, and size. Galls of every kind, however, derive their origin from the stings of insects, which generally belong to the class of flies. The female fly, by means of her sting, makes incisions in the leaves or branches of a tree, and in each incision she lays an egg. This egg is at first extremely minute; but it soon acquires

* Reaumur, vol. 12. page 412. edit. 12mo.

† Oeuvres de Bonnet, vol. 4. page 28. edit, 8vo.

a considerable bulk, and the gall has arrived at its full size before the worm is hatched. This gall seems to be analogous to the membranes which invest a foetus, and expand in all directions in proportion to its growth. That the eggs of oviparous animals grow while in the ovarium is universally known ; but it is singular that the eggs of gall-flies should grow after being separated from the body of the mother. These eggs must undoubtedly be furnished with external vessels, or a kind of roots, by which they extract juices from the internal cavity of the gall. Malpighius ascribes the origin of galls to a corrosive liquor introduced by the fly into the wound. But Reaumur, to account for the growth of a gall, thinks it unnecessary to have recourse to any supposed poisonous fluids, and attributes it to the superabundant nutritious juices derived to that particular part by the continual action of the absorbent vessels of the egg, joined to its heat, which may be compared to a little fire placed in the center of the tumour.

Whether these causes are sufficient to explain the growth of galls, we shall submit to the judgment of the reader. But, that the eggs deposited by the flies augment in size ; that worms proceed from them ; that these worms are nourished, and live a certain time imprisoned in the galls ; that they are there transformed into nymphs or chrysalids ; and, lastly, that they are metamorphosed into the winged insects, which, by gnawing an aperture through the gall, take their flight in the air ; are known and incontestable facts, of the truth of which every man may easily satisfy himself. Examine the common oak-galls, or those of any other tree ; if any of them happen to have no aperture, cut them gently open, and you are certain to find an egg, a worm, a chrysalis or a fly : But in such as are perforated by a cylindrical hole, not a vestige of an animal is discoverable. The galls which make an ingredient in the composition of ink are thick, and their

texture is very strong and compact : That the small animals they contain should be able to pierce through such a rigid substance is truly wonderful.

In the general order of Nature among oviparous animals, each egg includes one embryo only. A singular species of eggs, however, discovered by the celebrated Mr. Folks, late President of the Royal Society of London must be excepted. He found great numbers of them in the mud of small rivulets. In size they equalled the head of an ordinary pin. They were of a brown colour, and their surface was crustaceous, through which, by employing the microscope, several living worms were distinctly perceptible. By dexterously breaking the shell, he dislodged them ; and he found with surprise, that eight or nine worms were contained in, and proceeded from the same egg. They were all well formed, and moved about with great agility. Each of them was inclosed in an individual membranous covering, which was extremely thin and transparent. It were to be wished that the transformations of these extraordinary animals had been traced.

Some caterpillars, when about to transform, make a belt pass round their bodies. This belt is composed of an assemblage of filken threads spun by themselves, the ends of which they paste to the twigs of bushes, or other places where they choose to attach their bodies. They likewise fix their hind legs in a tuft of silk. After transformation, the chrysalids remain fixed in the same manner as before their metamorphosis. The belt is loose, and allows the chrysalis to perform its slow and feeble movements.

The whole moth-kind, as well as the silk-worm, immediately before their transformation into the chrysalis state, cover their bodies with a cocoon or clue of silk, though the nature of the silk, and their mode of spinning, are very different. The cocoons of the silk-worm are composed of pure silk. Their

figure is generally oval, which necessarily results from that of the animal's body upon which they are moulded. When spinning, they twist their bodies into the form of an S. The cod is produced by numberless circumvolutions and zigzags of the same thread. The silk is spun by an instrument situated near the mouth of the insect. The silky matter, before it is manufactured by the spinning instrument, appears under the form of a gum almost liquid, which is contained in two large reservoirs contorted like the intestines of larger animals, and which terminate at the spinning instrument by two parallel and slender conduits. Each conduit furnishes matter for one thread. The spinning instrument, as is evident when viewed by the microscope, unites the two threads into one. Thus a thread of silk, which has the appearance of being single, is in reality double, and spun with great dexterity. Some writers, who delight in the marvellous, ascribe foresight to the silk-worm in spinning its cod. The silk-worm, it must be acknowledged, acts as if it foresaw the approaching event. But the truth is, that, when the animal has acquired its full growth, its reservoirs of silk are completely filled. It then seems to be strongly stimulated to evacuate this glutinous matter. Its different movements and attitudes, while discharging the silk, produce those oval bundles which clothe and ornament vast numbers of the human species.

Another species of caterpillar constructs its cod in the form of a boat with the keel uppermost; but it consists not entirely of pure silk. The animal, with its teeth, detaches small triangular pieces of bark from a bush or a tree. These pieces of bark it pastes upon its body by means of a glutinous or silky substance, and they constitute a principal part of its cod.

Another species works also in wood, though not with equal art as the former. Its cod is composed entirely of small ir-

regular fragments of dried wood. These fragments the animal has the address to unite together, and to form of them a kind of a box which covers and defends its whole body. It accomplishes this purpose by moistening, for some moments, the pieces of wood in its mouth, and then attaches them to each other by a glutinous substance. Of this mixture the caterpillar forms a cod, the solidity of which is nearly equal to that of wood.

The most solitary of all insects are those who live in the internal parts of fruits. Many of them undergo their metamorphosis in the fruit itself, which affords them both nourishment and a safe retreat. They dig cavities in the fruit, which some of them either line with silk, or spin cods. Others leave the fruit, and retire to be transformed in the earth.

The metamorphosis of insects has been regarded as a sudden operation, because they often burst their shell or silky covering quickly, and immediately appear furnished with wings. But, by more attentive observation, it has been discovered that the transformation of caterpillars is a gradual process from the moment the animals are hatched till they arrive at a state of perfection. Why, it may be asked, do caterpillars so frequently cast their skins? The new skin, and other organs, were lodged under the old ones, as in so many tubes or cases, and the animal retires from these cases, because they have become too strait. The reality of these encasements has been demonstrated by a simple experiment. When about to molt or cast its skin, if the foremost legs of a caterpillar are cut off, the animal comes out of the old skin deprived of these legs. From this fact, Reaumur conjectured, that the chrysalis might be thus encased, and concealed under the last skin of the caterpillar. He discovered that the chrysalis, or rather the butterfly itself, was inclosed in the body of the caterpillar. The proboscis, the antennae, the

limbs, and the wings, of the fly are so nicely folded up, that they occupy a small space only under the two first rings of the caterpillar. In the first six limbs of the caterpillar are encased the six limbs of the butterfly. Even the eggs of the butterfly have been discovered in the caterpillar long before its transformation.

From these facts it appears, that the transformation of insects is only the throwing off external and temporary coverings, and not an alteration of the original form. Caterpillars may be considered as analogous to the foetuses of men and of quadrupeds. They live and receive nourishment in envelopes till they acquire such a degree of perfection as enables them to support the situation to which they are ultimately destined by Nature.

One would not readily believe that the *excrements* of a butterfly should be capable of exciting consternation in the minds of the people. But this event has frequently happened in different places and nations. Among many other prodigies which have terrified nations, *showers of blood* have been enumerated by historians. These showers of blood were supposed to portend great and calamitous events, as wars, the destruction of cities, and the overthrow of empires. About the beginning of July, in the year 1608, one of these pretended showers of blood fell in the suburbs of Aix, and for several miles round. This supposed shower of blood, M. de Reaumur remarks, would probably have been transmitted to us as a great and a real prodigy, if Aix had not then been possessed of a philosopher, who, amidst other species of knowledge, did not neglect the operations and oeconomy of insects. This philosopher was M. de Peiresc, whose life is written by Gassendi. This life contains a number of curious facts and observations. Among others, M. de Peiresc discovered the cause of the pretended shower of blood at Aix, which had created so general an alarm. About the be-

ginning of July, the walls of a church-yard adjacent to the city, and particularly the walls of the small villages in the neighbourhood, were observed to be spotted with large drops of a blood-coloured liquid. The people, as well as some theologians, considered those drops as the operation of sorcerers, or of the Devil himself. M. de Peiresc, about that time, had picked up a large and beautiful chrysalis, which he laid in a box. Immediately after its transformation into the butterfly state, M. de Peiresc remarked, that it had left a drop of blood-coloured liquor on the bottom of the box, and that this drop, or stain, was as large as a French sou. The red stains on the walls, on stones near the highways, and in the fields, were found to be perfectly similar to that on the bottom of M. de Peiresc's box. He now no longer hesitated to pronounce, that all those blood-coloured stains, wherever they appeared, proceeded from the same cause. The prodigious number of butterflies which he, at the same time, saw flying in the air, confirmed his original idea. He likewise observed, that the drops of the miraculous rain were never found in the middle of the city ; that they appeared only in places bordering upon the country ; and that they never fell upon the tops of houses, or upon walls more elevated than the height to which butterflies generally rise. What M. de Peiresc saw himself, he showed to many persons of knowledge, or of curiosity, and established it as an incontestable fact, that the pretended drops of blood were, in reality, drops of a red liquor deposited by butterflies.

To the same cause M. de Peiresc attributes some other showers of blood related by historians ; and it is worthy of remark, that all of them are said to have happened in the warm seasons of the year, when butterflies are most numerous. Among others, Gregory of Tours mentions a shower of blood which fell, in the time of Childebert, in different parts of Paris, and upon a certain house in the territory

of Senlis ; and, about the end of the month of June, another likewise fell under the reign of King Robert.

M. de Reaumur remarks, that almost all the butterflies which proceeded from different species of hairy caterpillars in his possession, voided at least one, and often several large drops of excrement, which had the colour of blood. The hairy caterpillar that feeds upon the leaves of the elm-tree, after its transformation, emits drops, the colour of which is of a more deep red than that of blood ; and, after being dried, their colour approaches to that of carmine. From another caterpillar of the elm, which is larger, and much more common than the former, proceeds a butterfly, that, immediately after its transformation, emits a great quantity of red excrement. This species of caterpillar, in particular years, is so numerous, that it lays bare the whole trees in certain districts. Myriads of them are transformed into chrysalids about the end of May or beginning of June. When about to undergo their metamorphosis, they often attach themselves to the walls, and even enter into the country houses. If these butterflies were all brought forth at the same time, and flew in the same direction, their number would be sufficient to form small clouds, to cover the stones, &c. of particular districts with blood-coloured spots, and to convince those who wish to fright themselves, and to see prodigies, that a shower of blood had fallen during the night. Some of those hairy caterpillars which live in society upon nettles, likewise emit an excrementitious matter of a red colour. A thousand examples of the same kind might be enumerated. Hence the notion of miraculous or portentous showers of blood should be forever banished from the minds of men.

I would not have said so much upon this subject, if I had not considered it to be the duty of every man, when it is in his power, to remove popular prejudices, especially when

they have a direct tendency to terrify the minds of men, and to cherish ignorance and superstition.

We not only read of showers, but, what seems to be more unaccountable, of fountains running occasionally with blood instead of water. Sir David Dalrymple, one of the Senators of the College of Justice in Scotland, a gentleman not more distinguished by his learning and deep research, than by his scrupulous integrity and propriety of conduct, relates, in his Annals of Scotland*, upon the authority of Hoveden and Benedictus Abbas, that, in the year 1184, ‘A fountain near Kilwinning†, in the shire of Ayr, ran blood for eight days and eight nights without intermission. This portent had frequently appeared, but never for so a long space. In the opinion of the people of the country, it prognosticated the effusion of blood. Benedictus Abbas, and R. Hoveden, relate the story of this portent with perfect credulity. Benedictus Abbas improves a little upon his brother ; for he is positive that the fountain flowed with *pure* blood.’ If Kilwinning, like Aix, had possessed such a philosopher as Peiresc, the redness of the water, if ever it did appear, would have received a most satisfactory explanation.

Transformations are not peculiar to animals. All organized bodies pass through successive changes. Plants, of course, are not exempted from mutation. What an amazing difference between an acorn and a stately oak ? The seeds of plants may be compared to the chrysalids of butterflies. The seed, like the chrysalis, contains, in miniature, all the parts of the future plant. These parts require only time, and other circumstances necessary to vegetation, for their complete evolution. How different are the seed-leaves from those of the plum ? Beside the general changes arising from growth, plants undergo a number of meta-

* Vol. I. page 298.

† A Scottish village.

metamorphoses from other causes. In northern climates, if we except a few evergreens, trees, during winter, are entirely stripped of their leaves. Instead of the pleasant emotions excited by the variety of figures, movements, colours, and fragrance of the leaves, flowers, and fruit, during the spring and summer, nothing is exhibited in winter but the bare stems and branches. In this state, the trees of the forest have a lugubrious appearance, and remind us of death and of skeletons. Very different are the emotions we feel in the spring, when the buds begin to burst, and the leaves to expand. When summer approaches, another beautiful change takes place. The flowers, with all their splendour of colours, and sweetnes of flavours, are then highly delightful to our senses. After performing the office of cherishing and protecting the tender fruit for some time, the flowers drop off, and a new change is exhibited. When the flowers fall, the young fruit appear, and gradually grow to maturity, perpetually presenting varieties in their magnitude, colour, odour, and flavour. When the fruit or seeds are fully ripe, they are gathered for the use of man, drop down upon the earth, or are devoured by birds and other animals. After this change happens, to which all the others were only preparatory, the leaves begin to shed, winter commences, and the same series of metamorphoses go on during the existence of the plant.

The changes just now mentioned are annual, and are ultimately intended to supply men and other animals with food. But plants are subjected to changes of form from causes of a more accidental nature. Varieties or changes in the figure of plants are often produced by soil, by situation, by culture, and by climate.

A plant is composed of the bark, the liber or inner circle, the wood, and the pith. The calyx or cup, the carolla or flower leaves, the stamina, and pistils, are only expansions of

the bark, the liber, the wood, and the pith. The petals of all flowers, in a natural state, are single. But, when transplanted into gardens, many of them, especially those which are furnished with numerous stamens, as the anemone, the poppy, the peony, the ranunculus, the daisy, the marigold, the rose, &c. double, or rather multiply their flower-leaves without end. This change from single to double, or monstrous flowers, as they are called, is produced by too great a quantity of nutricious juices, which prevents the substance of the liber from condensing into wood, and transforms the stamens into petals; and it not unfrequently happens, that, when these double flowering plants are committed to a poor soil, they become drier, are reduced to their natural state, and produce single flowers only. Plants which inhabit the valleys, when transported to the tops of mountains, or other elevated situations, not only become dwarfish, but undergo such changes in their general structure and appearance, that they are often thought to belong to a different species, though they are, in reality, only varieties of the same. Similar changes are produced when Alpine or mountain plants are cultivated in the valleys.

From culture and climate, likewise, plants undergo many changes. But this subject is so generally known, that to enlarge upon it would be entirely superfluous. We shall only remark, that the older botanists, when they perceived the same species of plants growing in a different soil, or in a different climate, assume such different appearances, considered and enumerated them as distinct species. But the modern botanists, to prevent the unnecessary multiplication of separate beings, have endeavoured to reduce all those varieties arising from fortuitous circumstances to their original species.

From these facts, and many others which might be mentioned, it appears, that, in both the animal and vegetable kingdoms, forms are perpetually changing. The mineral

kingdom is not less subject to metamorphoses ; but these belong not to our present subject. Though forms continually change, the quantity of matter is invariable. The same substances pass successively into the three kingdoms, and constitute, in their turn, a mineral, a plant, an insect, a reptile, a fish, a bird, a quadruped, a man. In these transformations, organized bodies are the principal agents. They change or decompose every substance that either enters into them, or is exposed to the action of their powers. Some they assimilate, by the process of nutrition, into their own substance ; others they evacuate in different forms ; and these evacuations make ingredients in the compositions of other bodies, as those of insects, whose multiplication is prodigious, and affords a very great quantity of organized matter for the nourishment and support of almost every animated being. Thus, from the apparently vilest and most contemptible species of matter, the richest productions derive their origin. The most beautiful flowers, the most exquisite fruits, and the most useful grain, all proceed from the bosom of corruption. The earth is continually bestowing fresh gifts upon us ; and her powers would soon be exhausted, if what she perpetually gives were not perpetually restored to her. It is a law of Nature, that all organized bodies should be decomposed, and gradually transformed into earth. While undergoing this species of dissolution, their more volatile particles pass into the air, and are diffused through the atmosphere. Thus animals, at least portions of them, are buried in the air, as well as in the earth, or in water. These floating particles soon enter into the composition of new organized beings, who are themselves destined to undergo the same revolutions. This circulation of organized matter has continued since the commencement of the world, and will proceed in the same course till its final destruction.

With regard to the intentions of nature in changing forms, a complete investigation of them exceeds the powers of human research. One great intention, from the examples above enumerated, cannot escape observation. In the animal world, every successive change is a new approach to the perfection of the individuals. Men, and the larger animals, some time after the age of puberty, remain stationary, and continue to multiply their species for periods proportioned to their respective species. When those periods terminate, they gradually decay till their final dissolution. The same observation is applicable to the insect tribes, whose transformations strike us with wonder. The caterpillar repeatedly moults or casts off its skin. The butterfly existed originally in the body of the caterpillar; but the organs of the fly were too soft, and not sufficiently unfolded. It remains unfit to encounter the open air, or to perform the functions of a perfect animal, till some time after its transformation into a chrysalis. It then bursts through its envelope, arrives at a state of perfection, multiplies its species, and dies. All the changes in the vegetable kingdom tend to the same point. In the process of growing, they are perpetually changing forms till they produce fruit, and then they decay. Some plants, like caterpillars, go through all their transformations, death not excepted, in one year. But others, like man and the larger animals, beside the common changes produced by growth and the evolution of different organs, continue for many years in a state of perfection before the periods of decay and of dissolution arrive. But these perennial plants undergo, every year, all the vicissitudes of the annuals. They every year increase in magnitude, send forth new leaves and branches, ripen and disseminate their seeds, and, during winter, remain in a torpid state, or suffer a temporary death. These annual changes in trees, &c. have some resemblance to those of animals which produce at certain stated seasons only.

The distribution of life to an immensity of successive individuals seems to be another intention of Nature in changing forms, and in the dissolution of her productions. Were the existence of individuals perpetual, or were it prolonged for ten times the periods now established, life would be denied to myriads of animated beings, who enjoy their present limited portion of happiness,

CHAPTER XIII.

Of the Habitations of Animals.

MANY animals, as well as those of the human species, are endowed by Nature with an architectonic faculty. This faculty is bestowed upon them for a number of wise and useful purposes. It enables them to construct proper habitations for concealing themselves, for defending them against the attacks of their enemies, for sheltering and cherishing their young, and for protecting them from the injuries of the weather.

All animals of the same species, when not restrained by accidental causes, uniformly build in the same style, and use the same materials. From this general rule man is to be excepted. Possessed of a superior number of instincts, of which the reasoning faculty is a result*, he can build in any style, and employ such materials as his taste, his fancy, or the purposes for which the fabric is intended, shall direct him. A cottage or a palace are equally within the reach of his powers. In treating of this subject, we mean not to trace the progress of human architecture, which, in the earlier stages of society, is extremely rude, but to confine ourselves to that of the inferior tribes of animated beings.

With regard to *quadrupeds*, many of them employ no kind of architecture, but live continually, and bring forth their young, in the open air. When not under the immediate protection of man, these species, in rough or stormy weather, shelter themselves among trees or bushes, retire under the coverture of projecting rocks, or the sides of hills opposite to those from which the wind proceeds. Beside these arts of defence, to which the creatures are prompted by

* See Chap. V. Of Instinct.

instinct and experience, Nature furnishes them, during the winter months, with a double portion of long hair, which protects them from cold, and other assaults of the weather.

Of the quadrupeds that make or choose habitations for themselves, some dig holes in the earth, some take refuge in the cavities of decayed trees, and in the clefts of rocks, and some actually construct cabins or houses. But the artifices they employ, the materials they use, and the situations they select, are so various, and so numerous, that our plan necessarily limits us to a few of the more curious examples.

The Alpine marmot is a quadruped about sixteen inches in length, and has a short tail. In figure, the marmots have some resemblance both to the rat and to the bear. When tamed, they eat every thing presented to them, as flesh, bread, fruit, roots, pot-herbs, insects, &c. They delight in the regions of frost and of snow, and are only to be found on the tops of the highest mountains. These animals remain in a torpid state during winter. About the end of September or the beginning of October, they retire into their holes, and never come abroad again till the beginning of April. Their retreats are formed with much art and precaution. With their feet and claws, which are admirably adapted to the purpose, they dig the earth with amazing quickness, and throw it behind them. They do not make a simple hole, or a straight or winding tube, but a kind of gallery in the form of a Y, each branch of which has an aperture, and both terminate in a capacious apartment, where several of the animals lodge together. As the whole operation is performed on the declivity of a mountain, this innermost apartment is alone horizontal. Both branches of the Y are inclined. One of the branches descends under the apartment, and follows the declivity of the mountain. This branch is a kind of aqueduct, and receives and carries off the excrements of the animals; and the other, which rises above the

principal apartment, is used for coming in and going out. The place of their abode is well lined with moss and hay, of which they lay up great store during the summer. They are social animals. Several of them live together, and work in common when forming their habitations. Thither they retire during rain, or upon the approach of danger. One of them stands sentinel upon a rock, while the others gambol upon the grass, or are employed in cutting it, in order to make hay. If the sentinel perceives a man, an eagle, a dog, or other dangerous animal, he alarms his companions by a loud whistle, and is himself the last that enters the hole. As they continue torpid during the winter, and, as if they foresaw that they would then have no occasion for victuals, they lay up no provisions in their apartments. But, when they feel the first approaches of the sleeping season, they shut up both passages to their habitation ; and this operation they perform with such labour and solidity, that it is more easy to dig the earth any where else than in such parts as they have thus fortified. At this time they are very fat, weighing sometimes twenty pounds. They continue to be plump for three months ; but afterwards they gradually decline, and, at the end of winter, they are extremely emaciated. When seized in their retreats, they appear rolled up in the form of a ball, and covered with hay. In this state, they are so torpid that they may be killed without seeming to feel pain. The hunters select the fattest for eating, and keep the young ones for taming. Like the dormice, and all the other animals which sleep during winter, the marmots are revived by a gradual and gentle heat : And it is remarkable, that those which are fed in houses, and kept warm, never become torpid, but are equally active and lively during the whole year.

We shall now give a short account of the operations and architecture of the *beaver*. This amphibious quadruped is

about three feet in length, and its tail, which is of an oval figure, and covered with scales, is eleven inches long. He uses his tail as a rudder to direct his course in the water. In places much frequented by man, the beavers neither associate nor build habitations. But, in the northern regions of both Continents, they assemble in the month of June or July, for the purposes of uniting into society and of building a city. From all quarters they arrive in numbers, and soon form a troop of two or three hundred. The operations and architecture of the beavers are so well described by the Count de Buffon, that we shall lay it before our readers nearly in his own words. The place of rendezvous, he remarks, is generally the situation fixed upon for their establishment, and it is always on the banks of waters. If the waters be flat, and seldom rise above their ordinary level, as in lakes, the beavers make no bank or dam. But in rivers or brooks, where the water is subject to risings and fallings, they build a bank, which traverses the river from one side to the other, like a sluice, and is often from 80 to 100 feet long, by 10 or 12 broad at the base. This pile, for animals of so small a size, appears to be enormous, and presupposes an incredible labour*. But the solidity with which the work is constructed is still more astonishing than its magnitude. The part of the river where they erect this bank is generally shallow. If they find on the margin a large tree, which can be made to fall into the river, they begin, by cutting it down, to form the principal basis of their work. This tree is often thicker than a man's body. By gnawing it at the bottom with their four cutting teeth, they in a short time accomplish their purpose, and always make the tree fall across the river. They next cut the branches from the trunk to make it lie level. These operations are performed by the joint industry of the whole community. Some of them at the same time traverse

* The largest beavers weigh only 50 or 60 pounds.

the banks of the river, and cut down smaller trees, from the size of a man's leg to that of his thigh. These they cut to a certain length, dress them into stakes, and first drag them by land to the margin of the river, and then by water to the place where the building is carrying on. These piles they sink down, and interweave the branches with the larger stakes. In performing this operation many difficulties are to be surmounted. In order to dress these stakes, and to put them in a situation nearly perpendicular, some of the beavers must elevate, with their teeth, the thick ends against the margin of the river, or against the cross tree, while others plunge to the bottom, and dig holes with their fore-feet to receive the points, that they may stand on end. When some are labouring in this manner, others bring earth, which they splash with their feet, and beat firm with their tails. They carry the earth in their mouths, and with their fore-feet. They transport earth in such quantities, that they fill with it all the intervals between the piles. These piles consist of several rows of stakes, of equal height, all placed opposite to each other, and extend from one bank of the river to the other. The stakes facing the under part of the river are placed perpendicularly; but those which are opposed to the stream slope upward to sustain the pressure of the water; so that the bank, which is ten or twelve feet wide at the base, is reduced to two or three at the top. Near the top, or thinnest part of the bank, the beavers make two or three sloping holes, to allow the surface-water to escape. These they enlarge or contract in proportion as the river rises or falls; and, when any breaches are made in the bank by sudden or violent inundations, they know how to repair them when the water subsides.

Hitherto all these operations were performed by the united force and dexterity of the whole community. They now separate into smaller societies, who build cabins or houses.

These cabins are constructed upon piles near the margin of the river or pond, and have two openings, one for the animals to the land, and the other for throwing themselves into the water. The form of these edifices is either round or oval, and they vary in size from four or five to eight or ten feet in diameter. Some of them consist of three or four stories. Their walls are about two feet thick ; and are raised perpendicularly upon planks, or plain stakes, which serve both for foundations and floors to their houses. When they consist of but one story, they rise perpendicularly a few feet only, afterwards assume a curved form, and terminate in a dome or vault, which answers the purpose of a roof. They are built with amazing solidity, and neatly plastered with a kind of stucco both within and without. In the application of this mortar the tails of the beavers serve for trowels, and their feet for flashing. Their houses are impenetrable to rain, and resist the most impetuous winds. In their construction, they employ different materials, as wood, stone, and a kind of sandy earth, which is not liable to be dissolved in water. The wood they use is generally of the light and tender kind, as alders, poplars, and willows, which commonly grow on the banks of rivers, and are more easily barked, cut, and transported, than the heavier and more solid species of timber. They always begin the operation of cutting trees at a foot or a foot and a half above the ground ; they labour in a sitting posture ; and, beside the convenience of this posture, they enjoy the pleasure of gnawing perpetually the bark and wood, which are their favourite food. Of these provisions they lay up ample stores in their cabins to support them during the winter. Each cabin has its own magazine, which is proportioned to the number of its inhabitants, who have all a common right to the store, and never pillage their neighbours. Some villages are composed of twenty or twenty-five cabins. But these large establishments are not

frequent ; and the common republics seldom exceed ten or twelve families, of which each have their own quarter of the village, their own magazine, and their separate habitation. The smallest cabins contain two, four, or six, and the largest eighteen, twenty, and sometimes thirty beavers. As to males and females, they are almost always equally paired. Upon a moderate computation, therefore, the society is often composed of 150 or 200, who all, at first, labour jointly in raising the great public building, and afterwards, in select tribes or companies, in making particular habitations. In this society, however numerous, an universal peace is maintained. Their union is cemented by common labours ; and it is perpetuated by mutual conveniency, and the abundance of provisions which they amass and consume together. A simple taste, moderate appetites, and an aversion to blood and carnage, render them destitute of the ideas of rapine and of war. Friends to each other, if they have any foreign enemies they know how to avoid them. When danger approaches, they advertise one another, by striking their broad tail on the surface of the water, the noise of which is heard at a great distance, and resounds through all the vaults of their habitations. Each individual, upon these occasions, consults his own safety ; some plunge into the water ; others conceal themselves within their walls, which can be penetrated only by the fire of heaven, or the steel of man, and which no animal will attempt either to open or to overturn. These retreats are not only safe, but neat and commodious. The floors are spread over with verdure : The branches of the box and of the fir serve them for carpets, upon which they permit not the smallest dirtiness. The window that faces the water answers for a balcony to receive the fresh air, and for the purpose of bathing. During the greater part of the day, the beavers sit on end, with their head and the anterior parts of their body elevated, and their posterior parts

funk in the water. The aperture of this window is sufficiently raised to prevent its being stopped up with the ice, which, in the beaver climates, is often two or three feet thick. When this accident happens, they slope the sole of the window, cut obliquely the stakes which support it, and thus open a communication with the unfrozen water. They often swim a long way under the ice. The continual habit of keeping their tail and posterior parts of their body in the water, appears to have changed the nature of their flesh; for that of their anterior parts, as far as the reins, has the taste and consistence of the flesh of land-animals; but that of the tail and posterior parts has the odour and all the other qualities of fish. The tail, which is a foot long, an inch thick, and five or six inches broad, is a genuine portion of a fish attached to the body of a quadruped: It is wholly covered with scales, and below the scales with a skin perfectly similar to that of large fishes. In September, the beavers collect their provisions of bark and of wood. Till the end of winter, they remain in their cabins, enjoy the fruits of their labours, and taste the sweets of domestic happiness. This is their time of repose, and their season of love. Knowing and loving one another, each couple unite, not by chance, but by taste and a real selection. The females bring forth in the end of winter, and generally produce two or three at a time. About this period they are left by the males, who retire to the country to enjoy the pleasures and the fruits of the spring. They return occasionally, however, to their cabins; but dwell there no more. The mothers continue in the cabins, and are occupied in nursing, protecting, and rearing their young, which in a few weeks are in a condition to follow their dams. The beavers assemble not again till autumn, unless their banks or cabins be injured by inundations; for, when accidents of this kind happen, they suddenly collect their forces, and repair the breaches that have been made.

This account of the society and operations of beavers, however marvellous it may appear, has been established and confirmed by so many credible eye-witnesses, that it is impossible to doubt of its reality.

The habitation where *moles* deposit their young merits a particular description ; because it is constructed with peculiar intelligence, and because the mole is an animal with which we are well acquainted. They begin by raising the earth, and forming a pretty high arch. They leave partitions, or a kind of pillars, at certain distances, beat and press the earth, interweave it with the roots of plants, and render it so hard and solid, that the water cannot penetrate the vault, on account of its convexity and firmness. They then elevate a little hillock under the principal arch ; upon the latter they lay herbs and leaves for a bed to their young. In this situation they are above the level of the ground, and, of course, beyond the reach of ordinary inundations. They are, at the same time, defended from the rains by the large vault that covers the internal one, upon the convexity of which last they rest along with their young. This internal hillock is pierced on all sides with sloping holes, which descend still lower, and serve as subterraneous passes for the mother to go in quest of food for herself and her offspring. These by-paths are beaten and firm, extend about twelve or fifteen paces, and issue from the principal mansion like rays from a centre. Under the superior vault we likewise find remains of the roots of the meadow saffron, which seem to be the first food given to the young. From this description, it appears, that the mole never comes abroad but at considerable distances from her habitation. Moles, like the beavers, pair ; and so lively and reciprocal an attachment subsists between them, that they seem to disrelish all other society. In their dark abodes they enjoy the placid habits of repose and of solitude, the art of securing themselves from injury, of al-

most instantaneously making an asylum or habitation, and of procuring a plentiful subsistence without the necessity of going abroad. They shut up the entrance of their retreats, and seldom leave them, unless compelled by the admission of water, or when their mansions are demolished by art.

The nidification of *Birds* has at all times deservedly called forth the admiration of mankind. In general, the nests of birds are built with an art so exquisite, that an exact imitation of them exceeds all the powers of human skill and industry. Their style of architecture, the materials they employ, and the situations they select, are as various as the different species. Individuals of the same species, whatever region of the globe they inhabit, collect the same materials, arrange and construct them in the same form, and make choice of similar situations for erecting their temporary habitations; for the nests of birds, those of the eagle-kind excepted, after the young have come to maturity, are forever abandoned by the parents.

To describe minutely the nests of birds would be a vain attempt. Such descriptions could not convey an adequate idea of their architecture to a person who had never seen one of those beautiful and commodious habitations, which even astonish and excite the amazement of children.

The different orders of birds exhibit great variety in the materials and structure of their nests. Those of the rapacious tribes are in general rude, and composed of coarse materials, as dried twigs, bents, &c. But they are often lined with soft substances. They build in elevated rocks, ruinous and sequestered castles and towers, and in other solitary retirements. The airy or nest of the eagle is quite flat, and not hollow, like those of other birds. The male and female commonly place their nest between two rocks, in a dry and inaccessible situation. The same nest, it is said, serves the eagle during life. The structure is so considerable, and com-

posed of such solid materials, that it may last many years. Its form resembles that of a floor. Its basis consists of sticks about five or six feet in length, which are supported at each end, and these are covered with several layers of rushes and heath. An eagle's nest was found in the Peak of Derbyshire, which Willoughby describes in the following manner : ' It was made of great sticks, resting one end on the edge of a rock, the other on a birch tree. Upon these was a layer of rushes, and over them a layer of heath, and on the heath rushes again ; upon which lay one young, and an addle egg ; and by them a lamb, a hare, and three heath pouts. The nest was about two yards square, and had no hollow in it.' But the butcher-birds, or shrikes, which are less rapacious than eagles and hawks, build their habitations in shrubs and bushes, and employ moss, wool, and other soft materials.

The birds belonging to the order of *Pies* in the ingenious Mr. Pennant's *Genera of Birds*, are extremely irregular in construing their nests. The common magpies build their nests in trees, and their structure is admirably contrived for affording warmth and protection to the young. The nest is not open at the top : It is covered, in the most dexterous manner, with an arch or dome, and a small opening in the side of it is left, to give the parents an opportunity of passing in and out at their pleasure. To protect their eggs and young from the attacks of other animals, the magpies place, all round the external surface of their nest, sharp briars and thorns. The long-tailed titmouse, or ox-eye, builds nearly like the wren, but with still greater art. With the same materials as the rest of the structure, the titmouse builds an arch over the top of the nest, which resembles an egg erected upon one end, and leaves a small hole in the side for a passage. Both eggs and young, by this contrivance, are defended from the injuries of the air, rain, cold, &c. That the young may have a soft and warm bed, she lines the in-

sides of the nest with feathers, down, and cobwebs. The sides and roof are composed of moss and wool interwoven in the most curious and artificial manner.

In treating of instinct, it was mentioned, that, in warm climates, many small birds suspended their nests on tender twigs of trees, to prevent them from being destroyed by the monkeys. In Europe, there are only three birds which build pensile nests, namely, the common oriola, the *parus pendulinus*, or hang-nest titmouse ; and another pensile nest, belonging to some unknown bird, was lately discovered by Mr. Pennant, near the house of Blair in Athole, in the north of Scotland. ‘In a spruce fir-tree,’ Mr. Pennant remarks, ‘was a hang-nest of some unknown bird, suspended at the four corners to the boughs. It was open at top, an inch and a half diameter, and two deep ; the sides and bottom thick ; the materials moss, worsted, and birch bark, lined with feathers*.’

Mr. Pennant, in his Indian Zoology, gives the following curious account of the manner in which the motacilla futoria, or taylor bird, builds its nest. ‘Had providence,’ Mr. Pennant remarks, ‘left the feathered tribes unendowed with any particular instinct, the birds of the torrid zone would have built their nests in the same unguarded manner as those of Europe ; but there the lesser species, having a certain prescience of the dangers that surround them, and of their own weakness, suspend their nests at the extreme branches of the trees : They are conscious of inhabiting a climate replete with enemies to them and their young ; with snakes that twine up the bodies of the trees, and apes that are perpetually in search of prey ; but, heaven-instructed, they elude the gliding of the one, and the activity of the other. The brute creation are more at enmity with one another than in other climates ; and the birds are

* Pennant’s Tour, vol. I, page 104. 3d edition.

‘ obliged to exert an unusual artifice in placing their little broods out of the reach of an invader. Each aims at the same end, though by different means ; some form their pensile nest in shape of a purse, deep and open at top, others with a hole in the side, and others, still more cautious, with an entrance at the very bottom, forming their lodge near the summit*. But the taylor-bird seems to have greater diffidence than any of the others : It will not trust its nest even to the extremity of a slender twig, but makes one more advance to safety by fixing it to the leaf itself. It picks up a dead leaf, and suspending to relate, sews it to the side of a living one†, its slender bill being its needle, and its thread some fine fibres, the lining feathers, goffamer, and down. Its eggs are white, the colour of the bird light yellow ; its length three inches ; its weight only three sixteenths of an ounce ; so that the materials of the nest, and its own size, are not likely to draw down a habitation that depends on so slight a tenure ‡.’

Birds of the gallinaceous or poultry kind lay their eggs on the ground. Some of them scrape a kind of a hole in the earth, and line it with a little long grass or straw.

It is a singular, though a well attested fact, that the cuckow makes no nest, and neither hatches nor feeds her own young. ‘ The hedge-sparrow,’ says Mr. Willoughby, ‘ is the cuckow’s nurse, but not the hedge-sparrow only, but also ring-doves, larks, finches. I myself, with many others, have seen a wag-tail feeding a young cuckow. The cuckow herself builds no nest ; but having found the nest of some little bird, she either devours or destroys the eggs she there finds,

* This instinct prevails also among the birds on the banks of the Gambia, in Africa, which abounds with monkeys and snakes : others, for the same end, make their nest in holes of the banks that overhang that vast river ; Purchas, vol. 2, page 1576.

† A nest of this bird is preserved in the British Museum.

‡ Pennant’s Indian Zoology, page 7.

' and, in the room thereof, lays one of her own, and so forsakes it. The silly bird returning, sits on this egg, hatches it, and, with a great deal of care and toil, broods, feeds, and cherishes the young cuckow for her own, until it be grown up and able to fly and shift for itself. Which thing seems so strange, monstrous, and absurd, that for my part I cannot sufficiently wonder there should be such an example in Nature; nor could I ever have been induced to believe that such a thing had been done by Nature's instinct, had I not with mine own eyes seen it. For Nature, in other things, is wont constantly to observe one and the same law and order, agreeable to the highest reason and prudence; which in this case is, that the dams make nests for themselves, if need be, fit upon their own eggs, and bring up their own young after they are hatched*. This oeconomy, in the history of the cuckow, is not only singular, but seems to contradict one of the most universal laws established among animated beings, and particularly among the feathered tribes, namely, the hatching and rearing of their offspring. Still, however, like the ostrich in very warm climates, though the cuckow neither hatches nor feeds her young, she places her eggs in situations where they are both hatched and her offspring brought to maturity. Here the stupidity of the one animal makes it a dupe to the rapine and chicane of the other; for the cuckow always destroys the eggs of the small bird before she deposits her own.

Most of the passerine or small tribes build their nests in hedges, shrubs, or bushes; though some of them, as the lark and the goat-sucker, build upon the ground. The nests of small birds are more delicate in their structure and contrivance than those of the larger kinds. As the size of their bodies, and likewise that of their eggs, are smaller, the materials of which their nests are composed are generally warmer.

* Willoughby's Ornithology, page 98.

Small bodies retain heat a shorter time than those which are large. Hence the eggs of small birds require a more constant supply of heat than those of greater dimensions. Their nests, accordingly, are built proportionally warmer and deeper, and they are lined with softer substances. The larger birds, of course, can leave their eggs for some time with impunity ; but the smaller kinds sit most assiduously ; for, when the female is obliged to go abroad in quest of food, the nest is always occupied by the male. When a nest is finished, nothing can exceed the dexterity of both male and female in concealing it from the observation of man, and of other destructive animals. If it is built in bushes, the pliant branches are disposed in such a manner as to hide it entirely from view. To conceal her retreat, the chaffinch covers the outside of her nest with moss, which is commonly of the same colour with the bark of the tree on which she builds. The common swallow builds its nest on the tops of chimneys ; and the martin attaches hers to the corners of windows, or under the eaves of houses. Both employ the same materials. The nest is built with mud well tempered by the bill, and moistened with water to make it more firmly cohere ; and the mud or clay is kept still firmer by a mixture of straw or grass. Within it is neatly lined with feathers. Willoughby, on the authority of Bontius, informs us, ‘ That, ‘ on the sea coast of the kingdom of China, a sort of small ‘ party-coloured birds, of the shape of swallows, at a certain ‘ season of the year, viz. their breeding time, come out of ‘ the midland country to the rocks ; and from the foam or ‘ froth of the sea-water dashing and breaking against the ‘ bottom of the rocks, gather a certain clammy, glutinous ‘ matter, perchance the sperm of whales, or other fishes, of ‘ which they build their nests, wherein they lay their eggs, ‘ and hatch their young. These nests the Chinese pluck ‘ from the rocks, and bring them in great numbers into the

‘ East Indies to sell ; which are esteemed by gluttons great delicacies, who, dissolving them in chicken or mutton broth, are very fond of them, preferring them far before oysters, mushrooms, or other dainty and lickerish morsels which most gratify the palate. These nests are of a hemispherical figure, of the bigness of a goose-egg, and of a substance resembling ising-glaſs*.’

Most of the cloven-footed water-fowls, or waders, lay their eggs upon the ground. But the spoon-bills and the common heron build large nests in trees, and employ twigs and other coarse materials ; and the storks build on churches, or on the tops of houses. Many of the webb-footed fowls lay their eggs likewise on the ground, as the terns, and some of the gulls and mergansers. But ducks pull the down from their own breasts to afford a warmer and more comfortable bed for their young. The auks, the guillemots, and the puffins or coulternebs, lay their eggs on the naked shelves of high rocks. The penguins, for the same purpose, dig large and deep holes under ground.

It is not unworthy of remark, that birds uniformly proportion the dimensions of their nests to the number and size of the young to be produced. Every species lays nearly a determined number of eggs. But, if one be each day abstracted from the nest, the bird continues to lay daily more till her number is completed. Dr. Lister, by this practice, made a swallow lay no less than nineteen eggs.

The habitations of *Insects* are next to be considered. On this branch of the subject, we shall first give some examples of abodes constructed by solitary workers, and next of those habitations which are executed by associated numbers.

In several preceding parts of this work, and particularly in the chapter upon Instinct, the reader will find some instances of the skill and industry exhibited by insects for the

* Willoughby's Ornithology, page 245.

convenient lodging and protection of their young. These it is unnecessary to repeat. We shall therefore proceed to give some examples of a different kind.

There are several species of bees distinguished by the appellation of *solitary*, because they do not associate to carry on any joint operations. Of this kind is the *mason-bee*, so called because it builds a habitation composed of sand and mortar. The nests of this bee are fixed to the walls of houses, and, when finished, have the appearance of irregular prominences arising from dirt or clay accidentally thrown against a wall or stone by the feet of horses. These prominencies are not so remarkable as to attract attention; but, when the external coat is removed, their structure is discovered to be truly admirable. The interior part consists of an assemblage of different cells, each of which affords a convenient lodgement to a white worm, pretty similar to those produced by the honey-bee. Here they remain till they have undergone all their metamorphoses. In constructing this nest, which is a work of great labour and dexterity, the female is the sole operator. She receives no assistance from the male. The manner in which the female mason-bees build their nests is the most curious branch of their history.

After choosing a part of a wall on which she is resolved to fix an habitation for her future progeny, she goes in quest of proper materials. The nest to be constructed must consist of a species of mortar, of which sand is the basis. She knows, like human builders, that every kind of sand is not equally proper for making good mortar. She goes, therefore, to a bed of sand and selects, grain by grain, the kind which is best to answer her purpose. With her teeth, which are as large and as strong as those of the honey-bee, she examines and brings together several grains. But sand alone will not make mortar. Recourse must be had to a cement similar to the slackened lime employed by masons. Our bee is unac-

quainted with lime, but she possesses an equivalent in her own body. From her mouth she throws out a viscid liquor, with which she moistens the first grain pitched upon. To this grain she cements a second, which she moistens in the same manner, and to the former two she attaches a third, and so on, till she has formed a mass as large as the shot usually employed to kill hares. This mass she carries off in her teeth to the place she had chosen for erecting her nest, and makes it the foundation of the first cell. In this manner she labours incessantly till the whole cells are completed, a work which is generally accomplished in five or six days. All the cells are similar, and nearly equal in dimensions. Before they are covered, their figure resembles that of a thimble. She never begins to make a second till the first be finished. Each cell is about an inch high, and nearly half an inch in diameter. But the labour of building is not the only one this female bee has to undergo. When a cell has been raised to one half or two thirds of its height, another occupation commences. She seems to know the quantity of food that will be necessary to nourish the young that is to proceed from the egg, from its exclusion till it acquires its full growth, and passes into the chrysalis state. The food which is prepared for the support of the young worm consists of the farina or powder of flowers, diluted with honey, which forms a kind of pap. Before the cell is entirely finished, the mason-bee collects from the flowers, and deposits in the cell, a large quantity of farina, and afterwards disgorges upon it as much honey as dilutes it, and forms it into a kind of paste, or syrup. When this operation is performed, she completes her cell, and, after depositing an egg in it, covers the mouth of it with the same mortar she uses in building her nest. The egg is now inclosed on all sides in a walled habitation hermetically sealed. A small quantity of air, however, gets admission to the worm, otherwise it could not exist. Reaumur discovered

that the air actually penetrated through this seemingly compact mason-work.

As soon as the first cell is completed, the mason-bee lays the foundation of another. In the same nest she often constructs seven or eight cells, and sometimes only three or four. She places them near each other, but not in any regular order. This industrious animal, after all her cells are constructed, filled with provisions, and sealed, covers the whole with an envelope of the same mortar, which, when dry, is as hard as a stone. The nest now is commonly of an oblong or roundish figure, and the external cover is composed of coarser sand than that of the cells. As the nests are almost as durable as the walls on which they are placed, they are often, in the following season, occupied and repaired by a stranger bee. Though inclosed with two hard walls, when the fly emerges from the chrysalis state, it first gnaws with its teeth a passage through the wall that sealed up the mouth of its cell, afterwards, with the same instruments, it pierces the still stronger and more compact cover which invests the whole nest; at last it escapes into the open air, and, if a female, in a short time, constructs a nest of the same kind with that which the mother had made. To all these facts, Du Hamel, Reaumur, and many other naturalists of credit and reputation, have been repeatedly eye-witnesses.

From the hardness of the materials with which the mason-bee constructs her nest, from the industry and dexterity she employs to protect her progeny from enemies of every kind, one should naturally imagine that the young worms were in perfect safety, and that their castle was impregnable. But, notwithstanding all these favourable precautions, the young of the mason-bee are often devoured by the instinctive dexterity of certain species of four-winged insects, distinguished by the name of *ichneumon flies*. These flies, when the mason-bee has nearly completed a cell, and filled it with por-

visions, deposit their own eggs in her cell. After the eggs of the ichneumon flies are hatched, their worms devour not only the provisions laid up by the mason-bee, but even her progeny whom she had laboured so hard, and with so much art and ingenuity, to protect. But the mason-bee has an enemy still more formidable. A certain fly employs the same stratagem of insinuating an egg into one of her cells before it is completed. From this egg proceeds a strong and rapacious worm, armed with prodigious fangs. The devastations of this worm are not confined to one cell. He often pierces through each cell in the nest, and successively devours both the mason-worms, and the provisions so anxiously laid up for their support by the mother. This stranger worm is afterwards transformed into a fine beetle, who is enabled to pierce the nest, and to make his escape.

The operations of another species of solitary bees, called *wood-piercers*, merit attention. These bees are larger than the queens of the honey-bee. Their bodies are smooth, except the fides, which are covered with hair. In the spring, they frequent gardens, and search for rotten, or at least dead wood, in order to make an habitation for their young. When a female of this species, for she receives no assistance from the male, has selected a piece of wood, or a decayed tree, she commences her labour by making a hole in it, which is generally directed toward the axis of the tree. When she has advanced about half an inch, she alters the direction of the hole, and conducts it nearly parallel to the axis of the wood. The size of her body requires that this hole should have a considerable diameter. It is often so large as to admit the finger of a man, and it sometimes extends from twelve to fifteen inches in length. If the thickness of the wood permits, she makes three or four of these long holes in its interior part. M. de Reaumur found three of these parallel holes in an old espalier post. Their diameters exceed-

ed half an inch. This labour, for a single bee, is prodigious; but, in executing it, she consumes weeks, and even months.

Around the foot of a post or piece of wood where one of these bees are working, little heaps of timber-dust are always found lying on the ground. These heaps daily increase in magnitude, and the particles of dust are as large as those produced by a hand-saw. The two teeth with which the animal is provided are the only instruments she employs in making such considerable perforations. Each tooth consists of a solid piece of shell, which in shape resembles an auger. It is convex above, concave below, and terminates in a sharp but strong point.

These long holes are designed for lodgings to the worms that are to proceed from the eggs which the bee is soon to deposit in them. But, after the holes are finished, her labour is by no means at an end. The eggs must not be mingled, or piled above each other. Every separate worm must have a distinct apartment, without any communication with the others. Each long hole or tube, accordingly, is only the outer walls of a house which is to consist of many chambers ranged one above another. A hole of about twelve inches in length she divides into ten or twelve separate apartments, each of which is about an inch high. The roof of the lowest room is the floor of the second, and so on to the uppermost. Each floor is about the thickness of a French crown. The floors or divisions are composed of particles of wood cemented together by a glutinous substance from the animal's mouth. In making a floor, she commences with gluing an annular plate of wood-dust round the internal circumference of the cavity. To this plate she attaches a second, to the second a third, and to the third a fourth, till the whole floor is completed. The undermost cell requires only a roof, and this roof is a floor to the second, &c.

We have hitherto described the wonderful assiduity of this animal in constructing her cells. But this operation, though great, and seemingly superior to the powers of a creature so small, is not her only labour. Before roofing in the first cell, she fills it with a paste or pap, composed of the farina of flowers moistened with honey. The quantity of paste is equal to the dimensions of the cell, which is about an inch high, and half an inch in diameter. Into this paste, which is to nourish the future worm, she deposits an egg. Immediately after this operation, she begins to form a roof, which not only incloses the first cell, but serves as a floor to the second. The second cell she likewise fills with paste, deposits an egg, and then covers the whole with another roof. In this manner she proceeds, till she has divided the whole tube into separate cells. A single tube frequently contains from ten to a dozen of these cells. When the cells are all inclosed, the busines of this laborious bee is finished, and she takes no more charge of her future progeny. The attention and solicitude bestowed by many other animals, in rearing their young, are exerted after birth. But, in the wood-piercing bee, as well as in many other insects, this instinctive attachment is reversed. All her labours and all her cares are exerted before she either sees her offspring, or knows that they are to exist. But, after the description that has been given of her amazing operations, she will not be considered as an unnatural mother. With astonishing industry and perseverance, she not only furnishes her young with safe and convenient lodgings, but lays up for them stores of provisions sufficient to support them till their final metamorphosis into flies, when the new females perform the same almost incredible operations for the protection and sustenance of their own offspring. When the young worm is hatched, it has scarcely sufficient space to turn itself in the cell, which is almost entirely filled with the pappy substance formerly

mentioned. But, as this substance is gradually devoured by the worm, the space in the cell necessarily enlarges in proportion to the growth and magnitude of the animal.

We are informed by M. de Reaumur*, that Mr. Pitot furnished him with a piece of wood, not exceeding an inch and a half in diameter, which contained the cells of a wood-piercing bee. He cut off as much of the wood as was sufficient to expose two of the cells to view, in each of which was a worm. The aperture he had made, to prevent the injuries of the air, he closed, by pasting on it a bit of glass. The cells were then almost entirely filled with paste. The two worms were exceedingly small, and, of course, occupied but little space between the walls of the cells and the mass of paste. As the animals increased in size, the paste daily diminished. He began to observe them on the 12th day of June ; and, on the 27th of the same month, the paste in each cell was nearly consumed, and the worm, folded in two, occupied the greater part of its habitation. On the 2d of July, the provisions of both worms were entirely exhausted ; and, beside the worms themselves, there remained in the cells only a few small, black, oblong grains of excrement. The five or six following days they fasted, which seemed to be a necessary abstinence, during which they were greatly agitated. They often bended their bodies, and elevated and depressed their heads. These movements were preparatory to the great change the animals were about to undergo. Between the 7th and 8th of the same month, they threw off their skins, and were metamorphosed into nymphs. On the 30th of July, these nymphs were transformed into flies similar to their parents. In a range of cells, the worms are of different ages, and, of course, of different sizes. Those in the lower cells are older than those in the superior ; because, after the bee has filled with paste and enclosed its first

* Tom. II, page 58. 12mo edition.

cell, a considerable time is requisite to collect provisions, and to form partitions for every successive and superior cell. The former, therefore, must be transformed into nymphs and flies before the latter. These circumstances are apparently foreseen by the common mother ; for, if the undermost worm, which is oldest, and soonest transformed, were to force its way upward, which it could easily do, it would not only disturb, but infallibly destroy all those lodged in the superior cells. But Nature has wisely prevented this devastation ; for the head of the nymph, and consequently of the fly, is always placed in a downward direction. Its first instinctive movements must, therefore, be in the same direction. That the young flies may escape from their respective cells, the mother digs a hole at the bottom of the long tube, which makes a communication with the undermost cell and the open air. Sometimes a similar passage is made near the middle of the tube. By this contrivance, as all the flies instinctively endeavour to cut their way downward, they find an easy and convenient passage ; for they have only to pierce the floor of their cells, which they readily perform with their teeth.

Another small species of solitary bees dig holes in the earth to make a convenient habitation for their young. Their nests are composed of cylindrical cells fixed to one another, and each of them, in figure, resembles a thimble. Their bottom, of course, is convex and rounded. The bottom of the second is inserted into the entry of the first ; and the entry of the second receives the bottom of the third. They are not all of the same length. Some of them are five lines long, others only four, and their diameters seldom exceed two lines. Sometimes only two of these cells are joined together ; and, at other times, we find three or four, which form a kind of cylinder. This cylinder is composed of alternate bands of two different colours : Those of the

narrowest, at the juncture of two cells, are white, and those of the broadest are of a reddish brown. The cells consist of a number of fine membranes, formed of a glutinous and transparent substance from the animal's mouth. Each cell our bee fills with the farina of flowers diluted with honey, and in this paste she deposits an egg. She then covers the cell, by gluing to its mouth a fine cellular substance taken from the leaves of some plant ; and in this manner she proceeds till her cylindrical nest is completed. The worms which are hatched from the eggs feed upon the paste, so carefully laid up for them by the mother, till they are transformed into flies similar to their parents.

Among wasps, as well as bees, there are solitary species, which carry on no joint operations. These solitary wasps are not less ingenious in constructing proper habitations for their young, nor less provident in laying up for them a store of nourishment sufficient to support them till they are transformed into flies, or have become perfect animals*. But, to give a detailed description of their operations would lead us into a prolixity of which the plan of our work does not admit.

On this subject, however, it cannot escape observation, that all the sagacity and laborious industry exerted in the various instances of animal architecture above described, have one uniform tendency. They are designed for the multiplication, protection, and nourishment of offspring. But many of them are so artful, and require such persevering labour, that the human mind is bewildered when it attempts to account for them. If we attend to the operations of quadrupeds, of birds, and of insects, most of them, like pregnant women, seem to know, from their own feelings, and foresight, not only their present condition, but what futurity is to produce. To solve this problem, recourse has been had by Des Cartes, by Buffon, and by other philosophers, to conformation of

* See page 128.

body and mechanical impulse. Their reasonings, however, though often ingenious, involve the subject in tenfold obscurity. We can hardly suppose that the animals actually foresee what is to happen, because, at first, they have not had even the aid of experience ; and, particularly in some of the insect tribes, the parents are dead before their young are produced. Pure instincts of this kind, therefore, must be referred to another source. In a chain of reasoning concerning the operations of Nature, such is the constitution of our minds, that we are under the necessity of resorting to an ultimate cause. What that cause is, it is the highest presumption in man to pretend to define. But, though we must forever remain ignorant of the cause, we are enabled to trace, and even to understand, partially, some of the effects ; and, from these effects, we perceive the most consummate wisdom, the most elegant and perfect contrivances to accomplish the multifarious and wonderful intentions of Nature. In contemplating the operations of animals, from man down to the seemingly most contemptible insect, we are necessarily compelled to refer them to pure instincts, or original qualities of mind, variegated by Nature according as the necessities, preservation, and continuation of the different species require. Let any man try to proceed a step farther, and, however he may deceive himself, and flatter his own vanity, he must find, at last, that he is clouded in obscurity, and that men who have a more correct and unprejudiced mode of thinking will brand him with absurdity, and of acting in direct opposition to the constitution and frame of the human mind.

I shall now give some examples of the operations of associating insects, who construct habitations by exerting a common and a mutual labour.

The skill and dexterity of the *honey-bees*, displayed in the construction of their combs or nests, have at all times called forth the admiration of mankind. They are composed of

cells regularly applied to each others sides. These cells are uniform hexagons or six-sided figures. In a bee-hive, every part is arranged with such symmetry, and so finely finished, that, if limited to the same materials, the most expert workman would find himself unqualified to construct a similar habitation, or rather a similar city.

Most Natural Historians have celebrated bees for their wisdom, for the perfection and harmony of their republican government, and for their persevering industry and wonderful oeconomy. All these splendid talents, however, the late ingenious Count de Buffon has endeavoured to persuade us, are only results of pure mechanism. But this is not the proper place to enter into a discussion of this point. It will fall more naturally to be treated of when we come to describe the societies established among different gregarious animals. We shall therefore, at present, confine ourselves chiefly to the mode in which bees construct their habitations.

In the formation of their combs, bees seem to resolve a problem which would not be a little puzzling to some geometers, namely, a quantity of wax being given, to make of it equal and similar cells of a determined capacity, but of the largest size in proportion to the quantity of matter employed, and disposed of in such a manner as to occupy in the hive the least possible space. Every part of this problem is completely executed by the bees. By applying hexagonal cells to each other's sides, no void spaces are left between them ; and, though the same end might be accomplished by other figures, yet they would necessarily require a greater quantity of wax. Besides, hexagonal cells are better fitted to receive the cylindrical bodies of these insects. A comb consists of two strata of cells applied to each other's ends. This arrangement both saves room in the hive, and gives a double entry into the cells of which the comb is composed. As a farther

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saving of wax, and preventing void spaces, the bases of the cells in one stratum of a comb serve for bases to the opposite stratum. In a word, the more minutely the construction of these cells are examined, the more will the admiration of the observer be excited. The walls of the cells are so extremely thin, that their mouths would be in danger of suffering by the frequent entering and issuing of the bees. To prevent this disaster, they make a kind of ring round the margin of each cell, and this ring is three or four times thicker than the walls.

It is difficult to perceive, even with the assistance of glass-hives, the manner in which bees operate when constructing their cells. They are so eager to afford mutual assistance, and, for this purpose, so many of them crowd together, and are perpetually succeeding each other, that their individual operations can seldom be distinctly observed. It has, however, been plainly discovered, that their two teeth are the only instruments they employ in modelling and polishing the wax. With a little patience and attention, we perceive cells just begun: We likewise remark the quickness with which a bee moves its teeth against a small portion of the cell. This portion the animal, by repeated strokes on each side, smooths, renders compact, and reduces to a proper thinness of consistence. While some of the hive are lengthening their hexagonal tubes, others are laying the foundations of new ones. In certain circumstances, when extremely hurried, they do not complete their new cells, but leave them imperfect till they have begun a number sufficient for their present exigencies. When a bee puts its head a little way into a cell, we easily perceive it scraping the walls with the points of its teeth, in order to detach such useless and irregular fragments as may have been left in the work. Of these fragments the bee forms a ball about the size of a pin-head, comes out of the cell, and carries this wax to another part of the work where it is needed. It no sooner leaves the

cell than it is succeeded by another bee, which performs the same office, and in this manner the work is successively carried on till the cell is completely polished.

The cells of bees are designed for different purposes. Some of them are employed for the accumulation and preservation of honey. In others, the female deposits her eggs, and from these eggs worms are hatched, which remain in the cells till their final transformation into flies. The drones or males are larger than the common or working bees ; and the queen, or mother of the hive, is much larger than either. A cell destined for the lodgment of a male or female worm must, therefore, be considerably larger than the cells of the smaller working bees. The number of cells destined for the reception of the working bees far exceeds those in which the males are lodged. The honey-cells are always made deeper and more capacious than the others. When the honey collected is so abundant that the vessels cannot contain it, the bees lengthen, and of course deepen the honey-cells.

Their mode of working, and the disposition and division of their labour, when put into an empty hive, do much honour to the sagacity of bees. They immediately begin to lay the foundations of their combs, which they execute with surprising quickness and alacrity. Soon after they begin to construct one comb, they divide into two or three companies, each of which, in different parts of the hive, is occupied with the same operations. By this division of labour, a greater number of bees have an opportunity of being employed at the same time, and, consequently, the common work is sooner finished. The combs are generally arranged in a direction parallel to each other. An interval or street between the combs is always left, that the bees may have a free passage, and an easy communication with the different combs in the hive. These streets are just wide enough to allow two bees to pass one another. Beside these parallel streets,

to shorten their journey when working, they leave several round cross passages, which are always covered.

Hitherto we have chiefly taken notice of the manner in which bees construct and polish their cells, without treating of the materials they employ. We have not marked the difference between the crude matter collected from flowers and the true wax. Every body knows that bees carry into their hives, by means of their hind thighs, great quantities of the farina or dust of flowers. After many experiments made by Reaumur, with a view to discover whether this dust contained real wax, he was obliged to acknowledge, that he could never find that wax formed any part of its composition. He at length discovered, that wax was not a substance produced by the mixture of farina with any glutinous substance, nor by trituration, or any mechanical operation. By long and attentive observation, he found that the bees actually eat the farina which they so industriously collect; and that this farina, by an animal process, is converted into wax. This digestive process, which is necessary to the formation of wax, is carried on in the second stomach, and perhaps in the intestines of bees. After knowing the place where this operation is performed, chymists will probably allow, that it is equally difficult to make real wax with the farina of flowers, as to make chyle with animal or vegetable substances, a work which is daily executed by our own stomach and intestines, and by those of other animals. Reaumur likewise discovered, that all the cells in a hive were not destined for the reception of honey, and for depositing the eggs of the female, but that some of them were employed as receptacles for the farina of flowers, a species of food that bees find necessary for the formation of wax, which is the great basis and raw material of all their curious operations. When a bee comes to the hive with its thighs filled with farina, it is often met near the entrance by some of its companions, who first take

off the load, and then devour the provisions so kindly brought to them. But, when none of the bees employed in the hive are hungry for this species of food, the carriers of the farina deposit their loads in cells prepared for that purpose. To these cells the bees resort, when the weather is so bad that they cannot venture to go to the fields in quest of fresh provisions. The carrying bees, however, commonly enter the hive loaded with farina. They walk along the combs beating and making a noise with their wings. By these movements they seem to announce their arrival to their companions. No sooner has a loaded bee made these movements, than three or four of those within leave their work, come up to it, and first take off its load, and then eat the materials it has brought. As a farther evidence that the bees actually eat the farina of flowers, when the stomach and intestines are laid open, they are often found to be filled with this dust, the grains of which, when examined by the microscope, have the exact figure, colour, and consistence of farina, taken from the antherae of particular flowers. After the farina is digested, and converted into wax, the bees possess the power of bringing it from their stomachs to their mouths. The instrument they employ in furnishing materials for constructing their waxen cells is their tongue. This tongue is situated below the two teeth or fangs. When at work, the tongue may be seen by the assistance of a lens and a glass-hive. It is then in perpetual motion, and its motions are extremely rapid. Its figure continually varies. Sometimes it is more sharp, at others it is flatter, and sometimes it is more or less concave, and partly covered with a moist paste or wax. By the different movements of its tongue the bee continues to supply fresh wax to the two teeth, which are employed in raising and fashioning the walls of its cell, till they have acquired a sufficient height. As soon as the moist paste or wax dries, which it does almost instantane-

ously, it then assumes all the appearances and qualities of common wax. There is a still stronger proof that wax is the result of an animal process. When bees are removed into a new hive, and closely confined from the morning to the evening, if the hive chances to please them, in the course of this day several waxen cells will be formed, without the possibility of a single bee's having had access to the fields. Besides, the rude materials, or the farina of plants, carried into the hive, are of various colours. The farina of some plants employed by the bees is whitish ; in others it is of a fine yellow colour ; in others it is almost entirely red ; and in others it is green. The combs constructed with these differently coloured materials are, however, uniformly of the same colour. Every comb, especially when it is newly made, is of a pure white colour, which is more or less tarnished by age, the operation of the air, or by other accidental circumstances. To bleach wax, therefore, requires only the art of extracting such foreign bodies as may have insinuated themselves into its substance and changed its original colour.

Bees, from the nature of their constitution, require a warm habitation. They are likewise extremely solicitous to prevent insects of any kind from getting admittance into their hives. To accomplish both these purposes, when they take possession of a new hive, they carefully examine every part of it, and, if they discover any small holes or chinks, they immediately paste them firmly up with a resinous substance which differs considerably from wax. This substance was not unknown to the ancients. Pliny mentions it under the name of *propolis*, or bee-glue. Bees use the propolis for rendering their hives more close and perfect, in preference to wax, because the former is more durable, and more powerfully resists the vicissitudes of weather than the latter. This glue is not, like wax, procured by an animal process. The bees collect it from different trees, as the poplars, the

birches, and the willows. It is a complete production of Nature, and requires no addition or manufacture from the animals by which it is employed. After a bee has procured a quantity sufficient to fill the cavities in its two hind thighs, it repairs to the hive. Two of its companions instantly draw out the propolis, and apply it to fill up such chinks, holes, or other deficiencies, as they find in their habitation. But this is not the only use to which bees apply the propolis. They are extremely solicitous to remove such insects or foreign bodies as happen to get admission into the hive. When so light as not to exceed their powers, they first kill the insect with their stings, and then drag it out with their teeth. But it sometimes happens that an ill-fated snail creeps into the hive. It is no sooner perceived than it is attacked on all sides and stung to death. But how are the bees to carry out a burden of such weight? This labour they know would be in vain. They are perhaps apprehensive that a body so large would diffuse, in the course of its putrefaction, a disagreeable or noxious odour through the hive. To prevent such hurtful consequences, immediately after the animal's death, they embalm it, by covering every part of its body with propolis, through which no effluvia can escape. When a snail with a shell gets entrance, to dispose of it gives much less trouble and expence to the bees. As soon as this kind of snail receives the first wound from a sting, it naturally retires within its shell. In this case, the bees, instead of pasting it all over with propolis, content themselves with gluing all round the margin of the shell, which is sufficient to render the animal forever immovably fixed.

But propolis, and the materials for making wax, are not the only substances these industrious animals have to collect. As formerly remarked, beside the whole winter, there are many days in summer in which the bees are prevented by the weather from going abroad in quest of provisions. They

are, therefore, under the necessity of collecting, and amassing in cells destined for that purpose, large quantities of honey. This sweet and balsamic liquor they extract, by means of their proboscis or trunk, from the nectariferous glands of flowers. The trunk of a bee is a kind of rough cartilaginous tongue. After collecting a few small drops of honey, the animal with its proboscis conveys them to its mouth and swallows them. From the oesophagus or gullet, it passes into the first stomach, which is more or less swelled in proportion to the quantity of honey it contains. When empty, it has the appearance of a fine white thread: But, when filled with honey, it assumes the figure of an oblong bladder, the membrane of which is so thin and transparent, that it allows the colour of the liquor it contains to be distinctly seen. This bladder is well known to children who live in the country. They cruelly amuse themselves with catching bees, and tearing them asunder, in order to suck the honey. A single flower furnishes but a small quantity of honey. The bees are, therefore, obliged to fly from one flower to another till they fill their first stomachs. When they have accomplished this purpose, they return directly to the hive, and disgorge in a cell the whole honey they have collected. It not unfrequently happens, however, that, when on its way to the hive, it is accosted by a hungry companion. How the one can communicate its necessity to the other, it is perhaps impossible to discover. But the fact is certain, that, when two bees meet in this situation, they mutually stop, and the one whose stomach is full of honey extends its trunk, opens its mouth, which lies a little beyond the teeth, and like ruminating animals, forces up the honey into that cavity. The hungry bee knows how to take advantage of this hospitable invitation. With the point of its trunk it sucks the honey from the other's mouth. When not stopped on the road, the bee proceeds to the hive, and in the same manner offers its honey to those who are at work, as if it meant to prevent

the necessity of quitting their labour in order to go in quest of food. In bad weather, the bees feed upon the honey laid up in open cells; but they never touch these reservoirs when their companions are enabled to supply them with fresh honey from the fields. But the mouths of those cells which are destined for preserving honey during winter, they always cover with a lid or thin plate of wax.

Though not strictly connected with the present subject, we cannot refrain from giving some account of the ingenious Mr. Debray's discoveries concerning the sex of bees, and the manner in which their species is multiplied*. It was almost universally believed, both by ancients and moderns, that bees, like other animals, propagated by an actual intercourse of the male and female, though it never could be perceived by the most attentive observers. Pliny remarks, that *apium coitus visus est nunquam*; and even the indefatigable Reaumur, notwithstanding the many minute researches and experiments he made concerning every part of the oeconomy of bees, and though he represents the mother, or queen-bee, as a perfect Messalina, could never detect an actual intercourse. From this singular circumstance, Maraldi, in his observations upon bees†, conjectured that the eggs of bees, like those of fishes, were impregnated after they were deposited in the cells by the mother. He was farther confirmed in this opinion, by uniformly observing that a whitish liquid substance surrounded each egg which turned out to be fertile; but that those eggs round which no such substance was to be found were always barren. The working bees, or those which collect from flowers the materials of wax, have generally been considered as belonging to neither sex. But Mr. Schirach, a German Naturalist, in his *History of the Queen of the Bees*, maintains, that all the common bees are females in a disguised or barren

* See Philosophical Transactions, ann. 1777, Part I. page 15.

† Hist. de l'Acad. de Scien. ann. 1712.

state ; that the organs which distinguish the sex, and particularly the ovaria, are either obliterated, or, on account of their minuteness, have not hitherto been discovered ; that, in the early period of its existence, every one of these bees is capable of becoming a queen-bee, if the community choose to nurse it in a certain manner, and to raise it to that distinguished rank ; and that the queen-bee lays only two kinds of eggs, namely, those that are to produce drones or males, and those from which the working bees are to proceed.

The conjecture of Maraldi concerning the impregnation of the eggs after they are deposited in the cells, as well as the observations of Mr. Schirach concerning the sex of the working bees, have been completely verified by the experiments of Mr. Debray. Both Maraldi and Reaumur had long ago discovered, that, in every hive, beside the large drones, there are males or drones as small as the working bees. By means of glass-hives, Mr. Debray observed, that the queen-bee begins to deposit her eggs in the cells on the fourth or fifth day after the bees begin to work. On the first or second day after the eggs are placed in the cells, he perceived several bees sinking the posterior parts of their bodies into each cell, where they continued but a short time. After they had retired, he saw plainly with the naked eye a small quantity of whitish liquor left in the bottom of each cell that contained an egg. Next day he found that this liquor was absorbed into the egg, which, on the fourth day, is hatched. When the worms escape from the eggs, they are fed for eight or ten days with honey by the working bees. After that period they shut up the mouths of the cells, where the worms continue inclosed for ten days more, during which time they undergo their different transformations.

‘ I immersed,’ says Mr. Debray, ‘ all the bees in water ; and, when they appeared to be in a senseless state, I gently pressed every one of them between my fingers, in order to

‘ distinguish those armed with stings from those that had none, which last I might suspect to be males. Of these I found sixty-seven, exactly of the size of common bees, yielding a little whitish liquor on being pressed between the fingers. I killed every one, and replaced the swarm in a glafs-hive, where they immediately applied again to the work of making cells ; and, on the fourth or fifth day, very early in the morning, I had the pleasure to see the queen-bee depositing her eggs in those cells, which she did by placing the posterior part of her body in each of them. I continued to watch most part of the ensuing days, but could discover nothing of what I had seen before. The eggs, after the fourth day, instead of changing in the manner of caterpillars, were found in the same state they were in the first day.’ The next day about noon, the whole swarm forsook the hive, probably because the animals perceived, that, without the assistance of males, they were unqualified to multiply their species. To show the necessity of the eggs being fecundated by the male influence, Mr. Debray relates an experiment still more decisive.

‘ I took,’ says he, ‘ the brood-comb, which, as I observed before, had not been impregnated ; I divided it into two parts ; one I placed under a glafs-bell, No. 1. with honey-comb for the bees food ; I took care to leave a queen, but no drones, among the common bees I confined in it. The other piece of brood-comb I placed under another glafs-bell, No. 2. with a few drones, a queen, and a number of common bees proportioned to the size of the glafs. The result was, that, in the glass No. 1. no impregnation happened ; the eggs remained in the same state they were in when put into the glafs ; and, upon giving the bees their liberty on the seventh day, they all flew away, as was found to be the case in the former experiment : Whereas, in the glafs No. 2. I saw, the very day after the bees had been

' put under it, the impregnation of the eggs by the drones
' in every cell containing eggs ; the bees did not leave their
' hive on receiving their liberty ; and, in the course of twen-
' ty days, every egg underwent all the above mentioned ne-
' cessary changes, and formed a pretty numerous young col-
' ony, in which I was not a little startled to find *two* queens.'

The appearance of a new queen in a hive where there was no large or royal cell, made Mr. Debray conjecture that the bees are capable, by some particular means, of transforming a common subject into a queen. To ascertain the truth of this conjecture, he provided himself with four glass-hives, into each of which he put a piece of brood-comb taken from an old hive. These pieces of brood-comb contained eggs, worms, and nymphs. In each hive he confined a sufficient number of common bees, and some drones or males, but took care that there should be no queen.

' The bees,' Mr. Debray remarks, ' finding themselves
' without a queen, made a strange buzzing noise, which last-
' ed near two days, at the end of which they settled, and be-
' took themselves to work. On the fourth day, I perceived
' in each hive the beginning of a royal cell, *a certain indica-*
' *tion that one of the inclosed worms would soon be converted into a*
' *queen.* The construction of the royal cell being nearly ac-
' complished, I ventured to leave an opening for the bees
' to get out, and found that they returned as regularly as
' they do in common hives, and shewed no inclination to
' leave their habitation. But, to be brief, at the end of twen-
' ty days, I observed four young queens among the new pro-
' geny.'

To these experiments of Mr. Debray, it was objected, that the queen-bee, beside the eggs which she deposits in the royal cells, might likewise have laid royal or female eggs in the common cells ; and that the pieces of brood-comb, so successfully employed in his experiments for the production

of a queen, had always happened to contain one of these royal eggs, or rather one of the worms proceeding from them. But this objection was afterwards removed by many other accurate experiments, the results of which were uniformly the same; and the objectors to Mr. Debray's discovery candidly admit, that, when the community stands in need of a queen, the working-bees possess the power of raising a common subject to the throne; and that every worm of the hive is capable, under a certain course of management, of becoming the mother of a numerous progeny. This metamorphosis seems to be chiefly accomplished by a peculiar nourishment carefully administered to the worm by the working-bees, by which, and perhaps by other unknown means, the female organs, the germs of which previously existed in the embryo, are expanded, and all those differences in form and size, that so remarkably distinguish the queen from the working-bees, are produced.

It is always a fortunate circumstance when discoveries, which at first seem calculated solely to gratify curiosity, are capable of being turned to the advantage of society. Mr. Debray, accordingly, has not failed to point out the advantages that may be derived from his researches into the oeconomy and nature of bees. By his discovery, we are taught an easy mode of multiplying, without end, swarms, or new colonies, of these useful insects. Beside the great increase of honey, if this discovery were sufficiently attended to, considerable sums annually expended in importing wax into this kingdom from the Continent might be saved. The practice of this new art, Mr. Schirach informs us, has already extended itself through Upper Lusatia, the Palatinate, Bohemia, Bavaria, Silesia, and Poland. In some of these countries, it has excited the attention, and acquired the patronage of government. The Empress of Russia, who never loses sight of a single article by which the industry, and, of course, the

happiness of her subjects can be augmented, has sent a proper person to Klein Bautzen to be instructed in the general principles, and to learn all the minutiae of this new and important art.

Wasps, like the bees, associate in great numbers, and construct, with much dexterity and skill, a common habitation. There are many species of wasps, some of which unite into societies, and others spend their lives in perfect solitude. But, in this place, we shall confine our attention to the operations of the common associating wasp, an insect so well known, even to children, that it requires no description. Though bees, as well as wasps, are armed with a sting, yet the former may be regarded as a placid and harmless race. Bees are continually occupied with their own labours. Their chief care is to defend themselves ; and they never take nourishment at the expence of any other animal. Wasps, on the contrary, are ferocious animals, who live entirely on rapine and destruction. They kill and devour every insect that is inferior to them in strength. But, though warlike and rapacious in their general manners, they are polished and peaceable among themselves. To their young they discover the greatest tenderness and affection. For their protection and conveniency no labour is spared ; and the habitations they construct do honour to their patience, address, and sagacity. Their architecture, like that of the honey-bee, is singular, and worthy of admiration ; but the materials employed furnish neither honey nor wax. Impelled by an instinctive love of posterity, they, with great labour, skill, and assiduity, construct combs, which are likewise composed of hexagonal or six-sided cells. Though these cells are not made of wax, they are equally proper for the reception of eggs, and for affording convenient habitations to the worms which proceed from them till their transformation into wasps.

In general, the cells of the wasps are formed of a kind of paper, which with great dexterity, is fabricated by the animals themselves. The number of combs and cells in a wasp's nest is always proportioned to the number of individuals associated. Different species choose different situations for building their nests. Some expose their habitations to all the injuries of the air ; others prefer the trunks of decayed trees ; and others, as the common kind, of which we are principally treating, conceal their nests under ground. The hole which leads to a wasp's nest is about an inch in diameter. This hole is a kind of gallery mined by the wasps, is seldom in a straight line, and varies in length from half a foot to two feet, according to the distance of the nest from the surface of the ground. When exposed to view, the whole nest appears to be of a roundish form, and sometimes about twelve or fourteen inches in diameter. It is strongly fortified all round with walls or layers of paper, the surface of which is rough and irregular. In these walls, or rather in this external covering, two holes are left for passages to the combs. The wasps uniformly enter the nest by one hole, and go out by the other, which prevents any confusion or interruption to their common labours.

We are now arrived at the gates of this subterraneous city, which, though small, is extremely populous. Upon removing the external covering, we perceive that the whole interior part consists of several storeys or floors of combs, which are parallel to each other, and nearly in a horizontal position. Every storey is composed of a numerous assemblage of hexagonal cells, very regularly constructed with a matter resembling ash-coloured paper. These cells contain neither wax nor honey, but are solely destined for containing the eggs, the worms which are hatched from them, the nymphs, and the young wasps till they are able to fly. Wasps nests are not always composed of an equal number of

combs. They sometimes consist of fifteen, and sometimes of eleven only. The combs are of various diameters. The first, or uppermost, is often only two inches in diameter, while those of the middle sometimes exceed a foot. The lowest are also much smaller than the middle ones. All these combs, like so many floors or storeys ranged parallelly above each other, afford lodging to prodigious numbers of inhabitants. Reaumur computed, from the number of cells in a given portion of comb, that in a medium sized nest, there were at least 10,000 cells. This calculation gives an idea of the astonishing prolific powers of these insects, and of the vast numbers of individuals produced in a single season from one nest ; for every cell serves as a lodging to no less than three generations. Hence a moderately sized nest gives birth annually to 30,000 young wasps.

The different storeys of combs are always about half an inch high, which leaves free passages to the wasps from one part of the nest to another. These intervals are so spacious, that, in proportion to the bulk of the animals, they may be compared to great halls, or broad streets. Each of the larger combs is supported by about fifty pillars, which, at the same time, give solidity to the fabric, and greatly ornament the whole nest. The lesser combs are supported by the same ingenious contrivance. These pillars are coarse, and of a roundish form. Their bases and capitals, however, are much larger in diameter than towards the middle. By the one end they are attached to the superior comb, and by the other to the inferior. Thus between two combs there is always a species of rustic colonade. The wasps begin at the top and build downward. The uppermost and smallest comb is first constructed. It is attached to the superior part of the external covering. The second comb is fixed to the bottom of the first ; and in this manner the animals proceed till the whole operation is completed. The connecting pil-

lars are composed of the same kind of paper as the rest of the nest. To allow the wasps entries into the void spaces, roads are left between the combs and the external envelope or covering.

Having given a general idea of this curious edifice, it is next natural to inquire how the wasps build, and how they employ themselves in their abodes. But, as all these mysteries are performed under the earth, it required much industry and attention to discover them. By the ingenuity and perseverance of M. de Reaumur, however, we are enabled to explain some parts of their internal oeconomy and manners. This indefatigable naturalist contrived to make wasps, like the honey-bees, lodge and work in glass-hives. In this operation he was greatly assisted by the ardent affection which these animals have to their offspring ; for he found, that, though the nest was cut in different directions, and though it was exposed to the light, the wasps never deserted it, nor relaxed in their attention to their young. When placed in a glass-hive, they are perfectly peaceable, and never attack the observer, if he calmly contemplates their operations ; for, naturally, they do not sting, unless they are irritated.

Immediately after a wasp's nest has been transported from its natural situation, and covered with a glass-hive, the first operation of the insects is to repair the injuries it has suffered. With wonderful activity they carry off all the earth and foreign bodies that may have accidentally been conveyed into the hive. Some of them occupy themselves fixing the nest to the top and sides of the hive by pillars of paper similar to those which support the different stories or strata of combs ; others repair the breaches it has sustained ; and others fortify it by augmenting considerably the thickness of its external cover. This external envelope is an operation peculiar to wasps. Its construction requires great labour ;

for it frequently exceeds an inch and a half in thickness, and is composed of a number of strata or layers as thin as paper, between each of which there is a void space. This cover is a kind of box for inclosing the combs, and defending them from the rain which occasionally penetrates the earth. For this purpose it is admirably adapted. If it were one solid mass, the contact of water would penetrate the whole, and reach the combs. But, to prevent this fatal effect, the animals leave considerable vacuities between each vaulted layer, which are generally fifteen or sixteen in number. By this ingenious piece of architecture, one or two layers may be moistened with water, while the others are not in the least affected.

The materials employed by wasps in the construction of their nests are very different from those made use of by the honey-bee. Instead of collecting the farina of flowers, and digesting it into wax, the wasps gnaw with their two fangs, which are strong and serrated, small fibres of wood from the sashes of windows, the posts of espaliers, garden doors, &c. but never attempt growing or green timber. These fibres, which, though very slender, are often a line, or a twelfth part of an inch long. After cutting a certain number of them, the animals collect them into minute bundles, transport them to their nest, and, by means of a glutinous substance furnished from their own bodies, form them into a moist and ductile paste. Of this substance, or *papier mache*, they construct the external cover, the partitions of the nest, the hexagonal cells, and the solid columns which support the several layers or stories of combs.

The constructing of the nest occupies a comparatively small number of labourers. The others are differently employed. Here it is necessary to remark, that the republics of wasps, like those of the honey-bees, consist of three kinds of flies, males, females, and neuters. Like the bees, also,

the number of neuters far surpasses those of both males and females. The greatest quantity of labour is devolved upon the neuters; but they are not, like the neuter bees, the only workers; for there is no part of their different operations which the females, at certain times, do not execute. Neither do the males, though their industry is not comparable to that of the neuters, remain entirely idle. They often occupy themselves in the interior part of the nest. The greatest part of the labour, however, is performed by the neuters. They build the nest, feed the males, the females, and even the young. But, while the neuters are employed in these different operations, the others are abroad in hunting parties. Some attack with intrepidity live insects, which they sometimes carry entire to the nest; but they generally transport the abdomen or belly only. Others pillage butchers stalls, from which they often arrive with a piece of meat larger than the half of their own bodies. Others resort to gardens, and suck the juices of fruits. When they return to the nest, they distribute a part of their plunder to the females, to the males, and even to such neuters as have been usefully occupied at home. As soon as a neuter enters the nest, it is surrounded by several wasps, to each of whom it freely gives a portion of the food it has brought. Those who have not been hunting for prey, but have been sucking the juices of fruits, though they seem to return empty, fail not to regale their companions; for, after their arrival, they station themselves upon the upper part of the nest, and discharge from their mouths two or three drops of a clear liquid, which are immediately swallowed by the domestics.

The neuter wasps, though the most laborious, are the smallest; but they are extremely active and vivacious. The females are much larger, heavier, and slower in their movements. The males are of an intermediate size between that of the females and neuters. From these differences in size,

it is easy to distinguish the different kinds of those wasps which build their nests below the ground. In the hive of the honey-bee, the number of females is always extremely small ; but, in a wasp's nest, there are often more than three hundred females. During the months of June, July, and August, they remain constantly in the nest, and are never seen abroad except in the beginning of spring, and in the months of September and October. During the summer, they are totally occupied in laying their eggs and feeding their young. In this last operation, they are assisted by the other wasps ; for the females alone, though numerous, would be insufficient for the laborious task. A wasp's nest, when completed, sometimes consists of sixteen thousand cells, each of which contains an egg, a worm, or a nymph. The eggs are white, transparent, of an oblong figure, and differ in size, according to the kind of wasps which are to proceed from them. Some of them are no larger than the head of a small pin. They are so firmly glued to the bottoms of the cells, that it is with difficulty they can be detached without breaking. Eight days after the eggs are deposited in the cells, the worms are hatched, and are considerably larger than the eggs which gave birth to them. These worms demand the principal cares of the wasps who continue always in the nest. They feed them, as birds feed their young, by giving them, from time to time, a mouthful of food. It is astonishing to see with what industry and rapidity a female runs along the cells of a comb, and distributes to each worm a portion of nutriment. In proportion to the ages and conditions of the worms, they are fed with solid food, such as the bellies of insects, or with a liquid substance disgorged by the mother. When a worm is so large as to occupy its whole cell, it is then ready to be metamorphosed into a nymph. It then refuses all nourishment, and ceases to have any connection with the wasps in the nest. It shuts up the mouth of its cell,

with a fine silken cover, in the same manner as the silk-worm and other caterpillars spin their cods. This operation is completed in three or four hours, and the animal remains in the nymph state nine or ten days, when, with its teeth, it destroys the external cover of the cell, and comes forth in the form of a winged insect, which is either male, female, or neuter, according to the nature of the egg from which it was hatched. In a short time, the wasps newly transformed receive the food brought into the nest by the foragers in the fields. What is still more curious, in the course of the first day after their transformation, the young wasps have been observed going to the fields, bringing in provisions, and distributing them to the worms in the cells. A cell is no sooner abandoned by a young wasp, than it is cleaned, trimmed, and repaired by an old one, and rendered, in every respect, proper for the reception of another egg.

As formerly mentioned, wasps of different sexes differ greatly in size. The animals know how to construct cells proportioned to the dimensions of the fly that is to proceed from the egg which the female deposits in them. The neuters are six times smaller than the females, and their cells are built nearly in the same proportion. Cells are not only adapted for the reception of neuters, males, and females, but it is remarkable that the cells of the neuters are never intermixed with those of the males or females. A comb is entirely occupied with small cells fitted for the reception of neuter worms. But male and female cells are often found in the same comb. The males and females are of equal length, and, of course, require cells of an equal deepnes. But the cells of the males are narrower than those of the females, because the bodies of the former are never so thick as those of the latter.

This wonderful assemblage of combs, of the pillars which support them, and of the external envelope, is an edifice

which requires several months labour, and serves the animals one year only. This habitation, so populous in summer, is almost deserted in winter, and abandoned entirely in spring; for, in this last season, not a single wasp is to be found in a nest of the preceding year. It is worthy of remark, that the first combs of a nest are always accommodated for the reception of the neuter or working wasps. The city, of which the foundation has just been laid, requires a number of workmen. The neuter or working wasps are accordingly first produced. A cell is no sooner half completed than an egg of a neuter is deposited in it by the female. Of fourteen or fifteen combs inclosed in a common cover, the four last only are destined for the reception of males and females. Hence it uniformly happens, that, before the males and females are capable of taking flight, every wasp's nest is peopled with several thousand neuters or workers. But the neuters, who are first produced, are likewise the first that perish; for not one of them survives the termination even of a mild winter. It was remarked by the ancient naturalists, that some wasps lived one year only, and others two. To the former Aristotle gives the appellation of *operarii*, which are our workers or neuters, and to the latter *matrices*, which are our females.

The female wasps are stronger, and support the rigours of winter better than the males or neuters. Before the end of winter, however, several hundred females die, and not above ten or a dozen in each nest survive that season. These few females are destined for the continuation of the species. Each of them becomes the founder of a new republic. When a queen-bee departs from a hive in order to establish a new one, she is always accompanied with several thousand industrious labourers, ready to perform every necessary operation. But the female wasp has not the aid of a single labourer; for all the neuters are dead before the beginning of the spring. The female alone lays the foundation of a

new republic. She either finds or digs a hole under the earth, builds cells for the reception of her eggs, and feeds the worms which proceed from them. Whenever any of these neuter worms are transformed into flies, they immediately assist their parent in augmenting the number of cells and combs, and in feeding the young worms, which are daily hatching from the eggs. In a word, this female wasp, which in spring was perfectly solitary, without any proper habitation, and had every operation to perform, has, in autumn, several thousands of her offspring at her devotion, and is furnished with a magnificent palace, or rather city, to protect her from the injuries of the weather and from external enemies.

With regard to the male wasps, it is uncertain whether any of them survive the winter. But, though not so indolent as the males of the honey-bee, they can be of little assistance to the female ; for they never engage in any work of importance, such as constructing cells, or fortifying the external cover of the nest. They are never brought forth till towards the end of August ; and their sole occupation seems to be that of keeping the nest clean : They carry out every kind of filth, and the carcases of such of their companions as happen to die. In performing this operation, two of them often join, and, as mentioned in another place, when the load is too heavy, they cut off the head, and transport the dead animal at two times.

In the beginning of spring, when the female wasp has built her subterraneous habitation, which is soon to be peopled with thousands of flies, she has no occasion for the males ; because, in the month of September or October, she had been previously impregnated. The males and females are produced at the same time, and they are nearly equal in number. Like the male honey-bees, the male wasps are destitute of stings, but the females and neuters have stings, the poison-

ous liquor of which, when introduced into any part of the human body, excites inflammation, and creates a considerable degree of pain.

The habitations and the œconomy of the common *ant* are exceedingly curious. But, as they are so well known, and so obvious to inspection and examination, we shall not detain the reader with a description of them. To supply this defect, we shall give some account of the truly wonderful operations of the *termites*, which are generally called *white-ants**[†], though they belong to a different genus of insects. These animals infest Guinea, and all the tropical regions, where, for their depredations of property, they are greatly dreaded by the inhabitants ; from which circumstance they have received the name of *Fatalis* or *Destructor*.

The following abridged account of the *termites*, and of the wonderful habitations they build, is selected from an excellent description of them in a Letter from Mr. Henry Smeathman, of Clement's Inn, to Sir Joseph Banks, which was published in the Philosophical Transactions†. Though the nests, or rather hills, constructed by the termites, are mentioned by many travellers, their descriptions and observations are by no means so accurate as those of the ingenious Mr. Smeathman. Of these insects there are several species ; but they all resemble each other in form, and in their manner of living. They differ, however, as much as birds, in the stile of their architecture, and in the selection of the materials of which their nests are composed. Some build on the surface, or partly above and partly below the ground, and others on the trunks or branches of lofty trees.

Before describing the nests or hills, it is necessary to give some idea of the animals themselves, and of their general

* In the windward parts of Africa, they are denominated bugga, buggs ; in the West-Indies, wood lice, wood ants, or white-ants. They are likewise called piercers, eaters, or cutters, because they cut almost every thing in pieces.

† Vol. 71. part 1. page 139.

economy and manners. We shall confine ourselves to that species called *termites bellicosus*, or *fighters* because they are largest, and best known on the coast of Africa.

The republic of the *termites bellicosus*, like the other species of this genus, consists of three ranks, or orders of insects : 1. The working insects, which Mr. Smeathman distinguishes by the name of *labourers* ; 2. The fighters, or *soldiers*, which perform no kind of labour ; and, 3. The winged, or *perfect insects*, which are male and female, and capable of multiplying the species. These last Mr. Smeathman calls the *nobility* or *gentry* ; because they neither labour nor fight. The nobility alone are capable of being raised to the rank of kings and queens. A few weeks after their elevation to this state, they emigrate, in order to establish new empires.

In a nest or hill, the labourers, or working insects, are always most numerous : There are at least one hundred labourers to one of the fighting insects or soldiers. When in this state, they are about a fourth of an inch in length, which is rather smaller than some of our ants. From their figure, and fondness for wood, they are very generally known by the name of *wood-lice*.

The second order, or soldiers, differ in figure from that of the labourers. The former have been supposed to be neuters, and the latter males. But, in fact, they are the same insects. They have only undergone a change of form, and made a nearer approach to the perfect state. They are now much larger, being half an inch in length, and equal in size to fifteen of the labourers. The form of the head is likewise greatly changed. In the labourer state, the mouth is evidently formed for gnawing or holding bodies : But, in the soldier state, the jaws being shaped like two sharp awls a little jagged, are destined solely for piercing or wounding. For these purposes they are very well calculated ; for they are as hard as a crab's claw, and placed in a strong horny

head, which is of a nut-brown colour, and larger than the whole body.

The figure of the third order, or that of the insect in its perfect state, is still more changed. The head, the thorax, and the abdömen, differ almost entirely from the same parts in the labourers and soldiers. Beside, the animals are now furnished with four large, brownish, transparent wings, by which they are enabled, at the proper season, to emigrate and to establish new settlements. In the winged or perfect state, they have likewise acquired the organs of generation, and are greatly altered in their size as well as in their figure. Their bodies now measure between six and seven tenths of an inch, their wings, from tip to tip, above two inches and a half, and their bulk is equal to that of thirty labourers, or two soldiers. Instead of active, industrious, and rapacious little animals, when they arrive at their perfect state, they become innocent, helpless, and dastardly. Their numbers are great ; but their enemies are still more numerous. They are devoured by birds, by every species of ants, by carnivorous reptiles, and even by the inhabitants of many parts of Africa. This last fact is attested by Piso, Margrave, De Laet, Konig, Moor, Sparman, and by many other travellers, as well as by Smeathman. After such devastation, it is surprising that a single pair should escape so many dangers. ‘ Some, however,’ says Mr. Smeathman, ‘ are so fortunate ; and being found by some of the labouring insects, that are continually running about the surface of the ground under their covered galleries, are *elected Kings* and *Queens* of new states ; all those who are not so elected and preserved certainly perish. The manner in which these labourers protect the happy pair from their innumerable enemies, not only on the day of the massacre of almost all their race, but for a long time after, will, I hope, justify me in the use of the term *election*. The little industrious creatures immedi-

'ately inclose them in a small chamber of clay suitable to
'their size, into which, at first, they leave but one small en-
'trance, large enough for themselves and the soldiers to go
'in and out, but much too little for either of the royal pair
'to make use of ; and, when necessity obliges them to make
'more entrances, they are never larger ; so that, of course,
'the voluntary subjects charge themselves with the task of pro-
'viding for the offspring of their sovereigns, as well as to work
'and to fight for them, until they have raised a progeny ca-
'pable at least of dividing the task with them.

'It is not till this, probably, that they consummate their
'marriage, as I never saw a pair of them joined. The busi-
'ness of propagation, however, soon commences ; and the
'labourers having constructed a small wooden nursery, carry
'the eggs and lodge them there as fast as they can obtain
'them from the queen.

'About this time a most extraordinary change begins to
'take place in the *queen*, to which I know nothing similar,
'except in the *pulex penetrans* of Linnaeus, the jigger of the
'West-Indies, and in the different species of *coccus*, *cochineal*.
'The abdomen of this female begins gradually to extend
'and enlarge to such an enormous size, that an *old queen* will
'have it increased so as to be *fifteen hundred or two thousand*
'times the bulk of the rest of her body, and *twenty or thirty*
'thousand times the bulk of a labourer, as I have found by
'carefully weighing and computing the different states. The
'skin between the segments of the abdomen extends in eve-
'ry direction ; and at last the segments are removed to half
'an inch distance from each other, though, at first, the
'length of the whole abdomen is not half an inch. I conjec-
'ture the animal is upwards of two years old when the abdo-
'men is increased to three inches in length : I have some-
'times found them of near twice that size. The abdomen is
'now of an irregular oblong shape, being contracted by the

' muscles of every segment, and is become one vast matrix
' full of eggs, which make long circumvolutions through an
' innumerable quantity of very minute vessels that circulate
' round the inside in a serpentine manner, which would exer-
' cise the ingenuity of a skilful anatomist to dissect and deve-
' lop. This singular matrix is not more remarkable for its
' amazing extension and size than for its peristaltic motion,
' which resembles the undulating of waves, and continues in-
' cessantly without any apparent effort of the animal ; so that
' one part or other, alternately, is rising and sinking in per-
' petual succession, and the matrix seems never at rest, but is
' always protruding eggs to the amount (as I have frequent-
' ly counted in old queens) of sixty in a minute, or eighty
' thousand and upward in one day of twenty-four hours.

' These eggs are instantly taken from her body by the at-
' tendants, (of whom there always are, in the royal chamber
' and the galleries adjacent, a sufficient number in waiting),
' and carried to the nurseries, which, in a great nest, may
' some of them be four or five feet distant in a straight line,
' and, consequently, much farther by their winding galleries.
' Here, after they are hatched, the young are attended and
' provided with every thing necessary until they are able to
' shift for themselves, and take their share of the labours of
' the community.'

We shall now endeavour to give some idea of the almost incredible architecture and oeconomy of these wonderful insects.

The nests of the *termites bellicosæ*, or wood-lice, are called *hills* by the natives of Africa, New Holland, and other hot climates. This appellation is highly proper ; for they are often elevated ten or twelve feet above the surface of the earth, and are nearly of a conical figure. These hills, instead of being rare phenomena, are so frequent in many places near Senegal, that, as described with great propriety by

Mons. Adanson, their number, magnitude, and closeness of situation, make them appear like villages of the Negroes. ‘ But, of all the extraordinary things I observed,’ says Mons. Adanson, ‘ nothing struck me more than certain eminences, which by their height and regularity, made me take them, at a distance, for an assemblage of Negroe huts, or a considerable village, and yet they were only the nests of certain insects. These nests are round pyramids, from eight to ten feet high, upon nearly the same base, with a smooth surface of rich clay, excessively hard and well built*.’ Jobson, in his history of Gambia, tells us, that ‘ the ant-hills are remarkably cast up in those parts by pismires, some of them twenty foot in height, of compasse to contayne a dozen of men, with the heat of the sun baked into that hardness, that we used to hide ourselves in the ragged topes of them, when we took up stands to shoot at deere or wild beasts †.’ Mr. Bosman remarks, in his description of Guinea, that ‘ the ants make nests of the earth about twice the height of a man ‡.’

Each of these hills is composed of an exterior and an interior part. The exterior cover is a large clay-shell, which is shaped like a dome. Its strength and magnitude are sufficient to inclose and protect the interior building from the injuries of the weather, and to defend its numerous inhabitants from the attacks of natural or accidental enemies. The external dome or cover is, therefore, always much stronger than the internal building, which is the habitation of the insects, and is divided with wonderful artifice and regularity into a vast number of apartments for the residence and accommodation of the king and queen, for the nursing of their progeny, and for magazines, which are always well stored with provisions.

* Adanson’s Voyage to Scnegal, 8vo, page 153.—337. Voyage de Senegal 4to, page 83.—99.

† Purchas’s Pilgrims, vol. 2. page 1570.

‡ Page 276.—493.

These hills make their first appearance in the form of conical turrets about a foot high. In a short time the insects erect, at a little distance, other turrets, and go on increasing their number and widening their bases, till their underworks are covered with these turrets, which the animals always raise highest in the middle of the hill, and, by filling up the intervals between each turret, collect them, at last, into one great dome.

‘The *royal chamber*,’ Mr. Smeathman remarks, ‘which is occupied by the king and queen, appears to be, in the opinion of this little people, of the most consequence, and is always situated as near the centre of the interior building as possible, and generally about the height of the common surface of the ground. It is always nearly in the shape of half an egg, or an obtuse oval, within, and may be supposed to represent a long oven. In the infant state of the colony, it is not above an inch, or thereabout, in length; but in time will be increased to six or eight inches, or more, in the clear, being always in proportion to the size of the queen, who, increasing in bulk as in age, at length requires a chamber of such dimensions.’

The entrances into the royal chamber will not admit any animal larger than the soldiers or labourers. Hence the king and queen, which last, when full grown, is a thousand times the weight of a king, can never possibly go out. The royal chamber is surrounded by an innumerable quantity of others, which are of different sizes, figures, and dimensions; but all of them are arched either in a circular or an elliptical form. These chambers either open into each other, or have communicating passages, which being always clear, are evidently intended for the conveniency of the soldiers and attendants, of whom, as will soon appear, great numbers are necessary. These apartments are joined by the magazines and nurseries. The magazines are chambers of clay, and are at

all times well stored with provisions, which, to the naked eye, seem to consist of the raspings of wood and plants which the termites destroy ; but, when examined by the microscope, they are found to consist chiefly of the gums or inspissated juices of plants, thrown together in small irregular masses. Of these masses, some are finer than others, and resemble the sugar about preserved fruits ; others resemble the tears of gum, one being quite transparent, another like amber, a third brown, and a fourth perfectly opaque.

The magazines are always intermixed with the nurseries, which last are buildings totally different from the rest of the apartments. They are composed entirely of wooden materials, which seem to be cemented with gums. Mr. Smeathman very properly gives them the appellation of *nurseries* ; because they are invariably occupied by the eggs, and the young ones, which first appear in the shape of labourers ; but they are as white as snow. These buildings are exceedingly compact, and are divided into a number of small irregular-shaped chambers, not one of which is half an inch wide. They are placed all round, and as near as possible to the royal apartments. When a nest or hillock is in the infant state, the nurseries are close to the royal apartment. But as, in process of time, the body of the queen enlarges, it becomes necessary, for her accommodation, to augment the dimensions of her chamber. She then, likewise, lays a greater number of eggs, and requires more attendants ; of course, it is necessary that both the number and dimensions of the adjacent apartments should be augmented. For this purpose, the small first built nurseries are taken to pieces, rebuilt a little farther off, made a size larger, and their number, at the same time, is increased. Thus the animals are continually employed in pulling down, repairing, or rebuilding their apartments ; and these operations they perform with wonderful sagacity, regularity, and foresight.

One remarkable circumstance regarding the nurseries must not be omitted. They are always slightly overgrown with a kind of mould, and plentifully sprinkled with white globules about the size of a small pin's head. These globules, Mr. Smeathman at first conjectured to be the eggs ; but, when examined by the microscope, they evidently appeared to be a species of mushroom, in shape resembling our eatable mushroom when young. When entire, they are white like snow a little melted and frozen again ; and, when, bruised, they seem to be composed of an infinite number of pellucid particles, approaching to oval forms, and are with difficulty separated from each other. The mouldiness seems likewise to consist of the same kind of substance*.

The nurseries are enclosed in chambers of clay, like those which contain the provisions ; but they are much larger.. In the early state of the nest, they are not bigger than an hazel nut ; but, in great hills, they are often as large as a child's head of a year old.

The royal chamber is situated nearly on a level with the surface of the ground, at an equal distance from all the sides of the building, and directly under the apex of the hill. On all sides, both above and below, it is surrounded by what are called the *royal apartments*, which contain only labourers and soldiers, who can be intended for no other purpose than to continue in the nest either to guard or serve their common *father* and *mother*, on whose safety the happiness, and, in the estimation of the Negroes, the existence of the whole community depends. These apartments compose an intricate

* Mr Konig, who examined the termites nests in the East-Indies, conjectures, that these mushrooms are the food of the young insects. This supposition implies, that the old ones have a method of providing for and promoting the growth of the mushroom ; 'a circumstance,' Mr. Smeathman remarks, 'which, however strange to those unacquainted with the sagacity of those insects, I will venture to say, from many other extraordinary facts I have seen of them, is not very improbable.'

labyrinth, which extends a foot or more in diameter from the *royal chamber* on every side. Here the nurseries and magazines of provisions begin ; and, being separated by small empty chambers and galleries, which surround them, and communicate with each other, are continued on all sides to the outward shell, and reach up within it two thirds or three-fourths of its height, leaving an open area in the middle under the dome, which resembles the nave of an old cathedral. This area is surrounded by large Gothic arches, which are sometimes two or three feet high next the front of the area, but diminish rapidly as they recede, like the arches of aisles in perspectives, and are soon lost among the innumerable chambers and nurseries behind them. All these chambers and passages are arched, and contribute mutually to support one another. The interior building, or assemblage of nurseries, chambers, and passages, has a flattish roof without any perforation. By this contrivance, if, by accident, water should penetrate the external dome, the apartments below are preserved from injury. The area has also a flattish floor, which is situated above the royal chamber. It is likewise water proof, and so constructed, that, if water gets admittance, it runs off by subterraneous passages, which are of an astonishing magnitude. ‘ I measured one of them,’ says Mr. Smeathman, ‘ which was perfectly cylindrical, and thirteen inches in diameter.’ These subterraneous passages are thickly lined with the same kind of clay of which the hill is composed, ascend the internal part of the external shell in a spiral form, and, winding round the whole building up to the top, intersect and communicate with each other at different heights. From every part of these large galleries a number of pipes, or smaller galleries, leading to different apartments of the building, proceed. There are likewise a great many which lead downward, by sloping descents, three and four feet perpendicular under ground, among the gravel, from

which the labouring termites select the finer parts, which, after being worked up in their mouths to the consistence of mortar, become that solid clay or stone of which their hills, and every apartment of their buildings, except the nurseries, are composed. Other galleries ascend and lead out horizontally on every side, and are carried under ground, but near the surface, to great distances. Suppose the whole nests within a hundred yards of a house were completely destroyed, the inhabitants of those at a greater distance will carry on their subterraneous galleries, and invade the goods and merchandizes contained in it by sap and mine, unless great attention and circumspection are employed by the proprietor.

Mr. Smeathman concludes his description of the habitations of the *termites bellicos*, with much modesty, in the following words : ‘ Thus I have described, as briefly as the subject would admit, and I trust without exaggeration, those wonderful buildings, whose size, and external form, have often been mentioned by travellers, but whose interior, and most curious parts are so little known, that I may venture to consider my account of them as new, which is the only merit it has ; for they are constructed upon so different a plan from any thing else upon the earth, and so complicated, that I cannot find words equal to the task.’

When a breach is made in one of the hills by an ax, or other instrument, the first object that attracts attention is the behaviour of the soldiers, or fighting insects. Immediately after the blow is given, a soldier comes out, walks about the breach, and seems to examine the nature of the enemy, or the cause of the attack. He then goes in to the hill, gives the alarm, and, in a short time, large bodies rush out as fast as the breach will permit. It is not easy to describe the fury these fighting insects discover. In their eagerness to repel the enemy, they frequently tumble down the sides of the hill, but recover themselves very quickly, and bite every thing

they encounter. This biting, joined to the striking of their forceps upon the building, makes a crackling or vibrating noise, which is somewhat shriller and quicker than the ticking of a watch, and may be heard at the distance of three or four feet. While the attack proceeds, they are in the most violent bustle and agitation. If they get hold of any part of a man's body, they instantly make a wound, which discharges as much blood as is equal to their own weight. When they attack the leg, the stain of blood upon the stocking extends more than an inch in width. They make their hooked jaws meet at the first stroke, and never quit their hold, but suffer themselves to be pulled away leg by leg, and piece after piece, without the smallest attempt to escape. On the other hand, if a person keeps out of their reach, and gives them no farther disturbance, in less than half an hour they retire into their nest, as if they supposed the wonderful monster that damaged their castle had fled. Before the whole soldiers have got in, the labouring insects are all in motion, and hasten toward the breach, each of them having a quantity of tempered mortar in his mouth. This mortar they stick upon the breach as fast as they arrive, and perform the operation with so much dispatch and facility, that, notwithstanding the immensity of their numbers, they never stop or embarrass one another. During this scene of apparent hurry and confusion, the spectator is agreeably surprised when he perceives a regular wall gradually arising and filling up the chasm. While the labourers are thus employed, almost all the soldiers remain within, except here and there one, who saunters about among six hundred or a thousand labourers, but never touches the mortar. One soldier, however, always takes his station close to the wall that the labourers are building. This soldier turns himself leisurely on all sides, and, at intervals of a minute or two, raises his head, beats upon the building with his forceps, and makes the vi-

brating noise formerly mentioned. A loud hiss instantly issues from the inside of the dome and all the subterraneous caverns and passages. That this hiss proceeds from the labourers is apparent ; for, at every signal of this kind, they work with redoubled quickness and alacrity. A renewal of the attack, however, instantly changes the scene. ‘ On the first stroke,’ Mr. Sneathman remarks, ‘ the labourers run into the many pipes and galleries with which the building is perforated, which they do so quickly, that they seem to vanish ; for in a few seconds all are gone, and the soldiers rush out as numerous and as vindictive as before. On finding no enemy, they return again leisurely into the hill, and very soon after, the labourers appear loaded as at first, as active, and as sedulous, with soldiers here and there among them, who act just in the same manner, one or other of them giving the signal to hasten the business. Thus the pleasure of seeing them come out to fight or to work, alternately, may be obtained as often as curiosity excites, or time permits ; and it will certainly be found, that the one order never attempts to fight, or the other to work, let the emergency be ever so great.’

It is exceedingly difficult to explore the interior parts of a nest or hill. The apartments which surround the royal chamber and the nurseries, and indeed the whole fabrick, have such a dependence on each other, that the breaking of one arch generally pulls down two or three. There is another great obstacle to our researches, namely, the obstinacy of the soldiers, who, says our author, ‘ fight to the very last, disputing every inch of ground so well as often to drive away the Negroes who are without shoes, and make white people bleed plentifully through their stockings. Neither can we let a building stand so as to get a view of the interior parts without interruption ; for, while the soldiers are defending the out-works, the labourers keep barricading all

'the way against us, stopping up the different galleries and
'passages which lead to the various apartments, particularly
'the royal chamber, all the entrances to which they fill up
'so artfully as not to let it be distinguishable while it remains
'moist ; and, externally, it has no other appearance than
'that of a shapeless lump of clay. It is, however, easily
'found from its situation with respect to the other parts of
'the building, and by the crowds of labourers and soldiers
'which surround it, who shew their loyalty and fidelity by
'dying under its walls. The royal chamber, in a large nest,
'is capacious enough to hold many hundreds of the atten-
'dants, besides the royal pair ; and you always find it full of
'them as it can hold. These faithful subjects never abandon
'their charge even in the last distress ; for, whenever I took
'out the royal chamber, and, as I often did, preserved it for
'some time in a large glass bowl, all the attendants continued
'running in one direction round the king and queen with
'the utmost solicitude, some of them stopping at the head of
'the latter, as if to give her something. When they came
'to the extremity of the abdomen, they took the eggs from
'her, and carried them away, and piled them carefully toge-
ther in some part of the chamber, or in the bowl under, or
'behind any pieces of broken clay which lay most conveni-
'ent for the purpose.'

In this chapter, I have given a succinct view of the sagacity, dexterity, and architectonic powers, exhibited in the construction of habitations by the different classes of animals. But I am not without apprehensions, that, in my endeavours to avoid prolixity, I may have, in some instances, degenerated into obscurity. Enough, however, I hope, has been said, either for the purposes of admiration or of reasoning ; and, therefore, I shall not anticipate the reflections of my readers, but proceed to the next subject.

CHAPTER XIV.

Of the Hostilities of Animals.

IN contemplating the system of animation exhibited in this planet, the only one of which we have any extensive knowledge, the mind is struck, and even confounded, with the general scene of havock and devastation which is perpetually, and every where, presented to our view. There is not, perhaps, a single species of animated beings, whose existence depends not, more or less, upon the death and destruction of others. Every animal, when not prematurely deprived of life by those who are hostile to it, or by accident, enjoys a temporary existence, the duration of which is longer or shorter according to its nature, and the rank it holds in the creation ; and this existence universally terminates in death and dissolution. This is an established law of Nature, to which every animal is obliged to submit. But this necessary and universal deprivation of individual life, though great, is nothing when compared to the havock occasioned by another law, which impels animals to kill and devour different species, and sometimes their own. In the system of Nature, death and dissolution seem to be indispensable for the support and continuation of animal life.

But, though almost every animal, in some measure, depends for its existence on the destruction of others, there are some species in all the different tribes or classes, which are distinguished by the appellation of *carnivorous* or *rapacious*, because they live chiefly, or entirely, on animal food. In the prosecution of this subject, therefore, we shall in the first place, mention some examples of animal hostility and rapacity ; and, in the next place, endeavour to point out such ad-

vantages as result from this apparently cruel institution of Nature. On the last branch of the subject, however, the reader must not expect to have every difficulty removed, and every question solved. Like all the other parts of the oeconomy of Nature, the necessity, or even the seeming cruelty and injustice, of allowing animals to prey upon one another, is a mystery which we can never be enabled completely to unravel. But we are not entirely without hopes of showing several important utilities which result from this almost universal scene of animal devastation.

Of all rapacious animals, *Man* is the most universal destroyer. The destruction of carnivorous quadrupeds, birds, and insects, is, in general, limited to particular kinds. But the rapacity of man has hardly any limitation. His empire over the other animals which inhabit this globe is almost universal. He accordingly employs his power, and subdues or devours every species. Of some of the quadruped tribes, as the horse, the dog, the cat, he makes domestic slaves; and, though in this country, none of these species is used for food, he either obliges them to labour for him, or keeps them as sources of pleasure and amusement. From other quadrupeds, as the ox, the sheep, the goat, and the deer kind, he derives innumerable advantages. The ox-kind, in particular, after receiving the emoluments of their labour and fertility, he rewards with death, and then feeds upon their carcasses. Many other species, though not commonly used as food, are daily massacred in millions for the purposes of commerce, luxury, and caprice. Myriads of quadrupeds are annually destroyed for the sake of their furs, their hides, their tusks, their odoriferous secretions, &c.

Over the feathered tribes the dominion of man is not less extensive. There is not a single species in the numerous and diversified class of birds, which he either does not, or may not, employ for the nourishment of his body. By his

sagacity and address he has been enabled to domesticate many of the more prolific and delicious species, as turkeys, geese, and the various kinds of poultry. These he multiplies without end, and devours at pleasure.

Neither do the inhabitants of the waters escape the rapacity of man. Rivers, lakes, and even the ocean itself, feel the power of his empire, and are forced to supply him with provisions. Neither air nor water can defend against the ingenuity, the art, and the destructive industry of the human species. Man may be said even to have domesticated some fishes. In artificial ponds, he feeds and rears carp, tench, perch, trout, and other species, and with them occasionally furnishes his table.

It might have been expected, that insects and reptiles, some of which have a most disgusting aspect, would not have excited the human appetite. But we learn from experience, that, in every region of the earth, many insects which inhabit both the earth and the waters, are esteemed as delicate articles of luxury. Even the viper, though its venom be deleterious, escapes not the all-devouring jaws of man.

Thus man holds, and too often exercises, a tyrannical dominion over almost the whole brute creation, not because he is the strongest of all animals, but because his intellect, though of a similar nature, is vastly superior to that of the most sagacious of the less favoured tribes. He reigns over the other animals, because, like them, he is not only endowed with sentiment, but because the powers of his mind are more extensive. He overcomes force by ingenuity, and swiftness by art and persevering industry. But the empire of man over the brute creation is not absolute. Some species elude his power by the rapidity of their flight, by the swiftness of their course, by the obscurity of their retreats, and by the element in which they live. Others escape him by the minuteness of their bodies; and, instead of acknowledging their sovereign,

others boldly attack him with open hostility. He is also insulted and injured by the stings of insects, and by the poisonous bites of serpents. In other respects, man's empire, though comparatively great, is very much limited. He has no influence on the universe, on the motions and affections of the heavenly bodies, or on the revolutions of the globe which he inhabits. Neither has he a general dominion over animals, vegetables, or minerals. His power reaches not species, but is confined to individuals. Every order of being moves on its course, perishes, or is renewed, by the irresistible power of Nature. Even man himself, hurried along by the general torrent of time and of Nature, cannot prolong his existence. He is obliged to submit to the universal law ; and, like all other organized beings, he is born, grows to maturity and dies. Though man has been enabled to subdue the animal creation by the superior powers of his mind, his empire, like all other empires, could not be firmly established previous to the institution of pretty numerous societies. Almost the whole of his power is derived from society. It matures his reason, gives exertion to his genius, and unites his forces. Before the formation of large societies, man was perhaps the most helpless and the least formidable of all animals. Naked, and destitute of arms, to him the earth was only an immense desert peopled with strong and rapacious monsters, by whom he was often devoured. Even long after this period, history informs us, that the first heroes were destroyers of wild beasts. But, after the human species had multiplied, and spread over the earth, and when, by means of society and the arts, man was enabled to conquer a considerable part of the globe, he forced the wild beasts gradually to retire to the deserts. He cleared the earth of those gigantic animals who, perhaps, now no longer exist, but whose enormous bones are still found in different regions, and are preserved in the cabinets of the curious. He

reduced the numbers of voracious and noxious species. He opposed the powers and the dexterity of one animal to those of another. Some he subdued by address, and others by force. In this manner he, in process of time, acquired to himself perfect security, and established an empire that has no other limits than inaccessible solitudes, burning sands, frozen mountains, or obscure caverns, which are occupied as retreats by a few species of ferocious animals.

Next to man, the carnivorous quadrupeds are the most numerous and the most destructive. Different parts of the earth are infested with lions, tigers, panthers, ounces, leopards, jaguars, cougars, lynxes, wild cats, dogs, jackals, wolves, foxes, hyaenas, civets, genets, polecats, martins, ferrets, ermines, gluttons, bats, &c. Though all these, and many other tribes of quadrupeds, live solely upon blood and carnage, yet some of them, as the tiger, the wolf, the hyaena, and many other inferior species, are much more rapacious and destructive than others. The lion, though surrounded with prey, kills no more than he is able to consume. But the tiger is grossly ferocious, and cruel without necessity. Though satiated with carnage, he perpetually thirsts for blood. His restless fury has no intervals, except, when he is obliged to lie in ambush for prey at the sides of lakes or rivers, to which other animals resort for drink. He seizes and tears in pieces a fresh animal with equal rage as he exerted in devouring the first. He desolates every country that he inhabits, and dreads neither the aspect nor the arms of man. He sacrifices whole flocks of domestic animals, and all the wild beasts which come within the reach of his terrible claws. He attacks the young of the elephant and rhinoceros, and sometimes even ventures to brave the lion. His predominant instinct is a perpetual rage, a blind and undistinguishing ferocity, which often impel him to devour his own young, and to tear their mother in pieces when she attempts to defend

them. He delights in blood, and glutts himself with it till he is intoxicated. He tears the body for no other purpose than to plunge his head into it, and to drink large draughts of blood, the sources of which are generally exhausted before his thirst is appeased. The tiger is perhaps the only animal whose ferocity is unconquerable. Neither violence, restraint, nor bribery, have any effect in softening his temper. With harsh or gentle treatment he is equally irritated. The mild and conciliating influence of society makes no impression on the obduracy and incorrigibleness of his disposition. Time, instead of softening the ferociousness of his nature, only exasperates his rage. He tears, with equal wrath, the hand which feeds him, as that which is raised to strike him. He roars and grins at the sight of every living being. Every animated object he regards as a fresh prey, which he devours before hand with the avidity of his eyes, menaces it with frightful groans, and often springs at it without regarding his chains, which only restrain, but cannot calm his fury.

In temperate climates, the wolf seems to exceed all other animals in the ferocity and rapaciousness of his disposition. When pressed with hunger, he braves every danger. He attacks all those animals which are under the protection of man, especially such as he can carry off with ease, as lambs, kids, and the smaller kinds of dogs. When successful in his expeditions, he returns often to the charge, till, after being chased and wounded by men and dogs, he retires, during the day to his den. In the night he again issues forth, traverses the country, roams round the cottages, kills all the animals which have been left without, digs the earth under the doors, enters with a terrible ferocity, and puts every living creature to death, before he chooses to depart, and carry off his prey. When these inroads happen to be fruitless, he returns to the woods, searches about with avidity, follows the track and the scent of wild beasts, and pursues them till

they fall a prey to his rapacity. In a word, when his hunger is extreme, he loses all idea of fear, attacks women and children, and sometimes men ; at last he becomes perfectly furious by excessive exertions, and generally falls a sacrifice to pure rage and distraction. When several wolves appear together, it is not an association of peace, but of war. It is attended with tumult and dreadful growlings, and indicates an attack upon some of the larger animals, as a stag, an ox, or a formidable mastive. This predatory expedition is no sooner ended than they separate, and every individual returns in silence to his solitude. Wolves are fond of human flesh. They have been known to follow armies, to come in troops to the field of battle, where bodies are carelessly interred, to tear them up, and to devour them with an insatiable avidity : And, when once accustomed to human flesh, these wolves ever after attack men, prefer the shepherd to the flock, devour women, and carry off children. Whole countries are sometimes obliged to arm, in order to destroy the wolves. It is a fortunate circumstance that these dangerous and destructive animals have been long totally extirpated from Great Britain and her islands.

Neither are the *feathered tribes* exempted from the general law of devastation. But the number of birds of prey, properly so called, is much less in proportion than that of carnivorous quadrupeds. Birds of prey are likewise weaker ; and, of course, the destruction of animal life they occasion is much more limited than the immense devastations daily committed by rapacious quadrupeds. But, as if tyranny never lost sight of its rights, great numbers of birds make prodigious depredations upon the inhabitants of the waters. A vast tribe of birds frequent the waters, and live solely upon fishes. In a certain sense, every species of bird may be said to be a bird of prey ; for almost the whole of them devour flies, worms, and other insects, either for food to themselves or

their young. Birds of prey, like carnivorous quadrupeds, are not so prolific as the milder and more inoffensive kinds. Most of them lay only a small number of eggs. The great eagle and the osprey produce only two eggs in a season. The pigeon, it may be said, lays no more. But it should be considered that the pigeon produces two eggs three, four, or five times, from spring to autumn. All birds of prey exhibit an obduracy and a ferociousness of disposition, while the other kinds are mild, cheerful, and gentle, in their aspect and manners. Most birds of prey expel their offspring from the nest, and relinquish them to their fate, before they are sufficiently able to provide for themselves. This cruelty is the effect of personal want in the mother. When prey is scanty, which often happens, she in a manner starves herself to support her young. But, when her hunger becomes excessive, she forgets her parental affection, strikes, expels, and sometimes, in a paroxysm of fury produced by want, kills her offspring. An aversion to society is another effect of this natural and acquired obduracy of temper. Birds of prey, as well as carnivorous quadrupeds, never associate. Like robbers, they lead a solitary and wandering life. Mutual attachment unites the male and the female; and, as they are both capable of providing for themselves, and can give mutual assistance in making war against other animals, they never separate, even after the season of love. The same pair are uniformly found in the same place; but they never assemble in flocks, nor even associate in families. The larger kinds, as the eagles, require a greater quantity of food, and, for that reason, never allow their own offspring, after they have become rivals, to approach the places which the parents frequent. But all those birds, and all those quadrupeds, which are nourished by the productions of the earth, live in families, are fond of society, and assemble in numerous flocks, without quarrelling or disturbing one another.

Both the earth and the air furnish examples of rapacious animals. In these elements, however, the number of carnivorous animals is comparatively small. But every inhabitant of the *waters* depends for its existence upon rapine and destruction. The life of every *fish* from the smallest to the greatest, is one continued scene of hostility, violence and evasion. Their appetite for food is almost insatiable. It impels them to encounter every danger. They are in continual motion ; and the object of all their movements is to devour other fishes, or to avoid their own destruction. Their desire for food is so keen and undistinguishing, that they greedily swallow every thing which has the appearance of animation. Those that have small mouths feed upon worms and the spawn of other fishes ; and those whose mouths are larger devour every animal, their own species not excepted, that can pass through their gullet. To avoid destruction, the smaller fry retire to the shallows, where the larger kinds are unable to pursue them. But, in the watery element, no situation is absolutely safe ; for, even in the shallows, the oyster, the scallop, and the muscle, lie in ambush at the bottom, with their shells open, and, when a small fish comes into contact with them, they instantly close their shells upon him, and devour at leisure their imprisoned prey. Neither is the hunting or pursuit of fishes confined to particular regions. Shoals of one species follow, with unwearyed ardour, those of another through vast tracts of the ocean. The cod pursues the whiting from the banks of Newfoundland to the southern coasts of Spain.

It is a remarkable circumstance in the history of animated Nature, that carnivorous birds and quadrupeds are less prolific than the inoffensive and associating kinds ; but, on the contrary, that the inhabitants of the waters, who are all carnivorous, are endowed with a most astonishing fecundity. All kinds of fishes, a few only excepted, are oviparous. Not

withstanding the amazing destruction of their eggs by the smaller fry that frequent the shores, by aquatic birds, and by the larger fishes, the numbers which escape are sufficient to supply the ocean with inhabitants, and to afford nourishment to a very great portion of the human race. A cod, for instance, according to the accurate computation of Lewenhoeck, produces, from one roe, above nine millions of eggs in a single season. The flounder lays annually above one million, and the mackarel more than five hundred thousand : An increase so great, if permitted to arrive at maturity, that the ocean itself, in a few centuries, would not be spacious enough to contain its animated productions. This wonderful fertility answers two valuable purposes. In the midst of numberless enemies it continues the respective species, and furnishes to all a proper quantity of nourishment.

We have thus seen that man, some quadrupeds, some birds, and all fishes, are carnivorous animals. But this system of carnage descends still lower. Many of the *insect* tribes derive their nourishment from putrid carcasses, from the bodies of living animals, or from killing and devouring weaker species. How many flies are daily sacrificed by spiders, a most voracious and a most numerous tribe of insects ? In return, spiders are greedily devoured by flies which are distinguished by the name of *ichneumons*. The number of these ichneumon flies is inconceivable ; and, if it were not for the prodigious havock they make upon caterpillars and other insects, the fruits of the earth would be entirely destroyed. Wasps are extremely fond of animal food. They frequent butchers stalls, and beat off the flesh fly, and every other insect that resorts thither for the purpose of depositing its eggs in the meat. Butchers take the advantage of this jealous warfare. They encourage the wasps, and make centinels of them, by giving them livers, which they prefer to more fibrous flesh, probably because they can cut livers more easily with their teeth.

The libella, dragon, or lady-fly, is well known by the beauty of its colours and the symmetry of its form. For these external qualities it has received the appellation of *lady-fly*. Its dispositions and its mode of life, however, are more ferocious and warlike than those of the Amazones. Like birds of prey, they hover about in the air, for the sole purpose of devouring almost every species of winged insect. They accordingly frequent marshy grounds, pools of water, and the margins of rivers, where insects most abound. Their appetite is so gross and voracious, that they not only devour small flies, but even the large flesh-fly, moths, and butterflies, of every kind.

It has been often said, that no animal spontaneously feeds upon its own species. This remark has probably been intended as an apology for, or at least a limitation to, the general system of carnage established by Nature. But the observation, whatever might have been its intention, is unhappily a result of ignorance ; for some quadrupeds, all fishes, and many insects, make no such discrimination. The weaker are uniformly preyed upon by the stronger. Reaumur put twenty of those caterpillars which feed upon the leaves of the oak into a vial. Though he regularly supplied them with plenty of fresh oak leaves, he observed that the number of dead ones daily increased. Upon a more attentive examination into the cause of this mortality, he found, that the stronger attacked with their teeth, killed, sucked out the vitals of their weaker companions, and left nothing but the head, feet, and empty skins. In a few days, one only of the twenty remained in life.

Caterpillars have myriads of external enemies, as birds of almost every kind, many of the smaller quadrupeds, their own species, and numberless insects. But this vast source of devastation is still augmented by what may be denominated their internal enemies. Many flies deposit their eggs in

the bodies of caterpillars. From these eggs proceed small maggots, which gradually devour the vitals of the animal in which they reside. When about to be transformed into chrysalids, they pierce the skin of the caterpillar, spin their pods, and remain on the empty skin till they assume the form of flies, and escape into the air to perform the same cruel office to another unfortunate reptile. Every person must recollect to have seen the colewort or cabbage caterpillar stuck upon old walls, or the windows of country cottages, totally covered with these chrysalids, which have the form of small maggots, and are of a fine yellow colour. One of the most formidable enemies of the caterpillar is a black worm, with six crustaceous legs. It is as long, and thicker than an ordinary sized caterpillar. In the fore part of the head it has two curved pincers, with which it quickly pierces the belly of a caterpillar, and never quits the prey till it is entirely devoured. The largest caterpillar is not sufficient to nourish this worm for a single day ; for it daily kills and eats several of them. These glutinous worms, when gorged with food, become inactive, and almost motionless. When in this satiated condition, young worms of the same species attack and devour them. Of all trees, the oak, perhaps, nourishes the greatest number of different caterpillars, as well as of different insects. Amongst others, the oak is inhabited by a large and beautiful beetle. This beetle frequents the oak, probably because that tree is inhabited by the greatest number of caterpillars. It marches from branch to branch, and, when disposed for food, attacks and devours the first caterpillar that comes in its way.

The pucerons, vine-fretters, or plant-lice, are very injurious to trees and vegetables of almost every kind. Their species are so numerous, and all of them are endowed with such a wonderful fertility, that we should expect to see the leaves, the branches, and the stems of every plant totally cov-

ered with them. But this astonishing fecundity, and the devastation these small insects would unavoidably produce among the vegetable tribes, is checked by numberless enemies. Myriads of insects of different classes, of different genera, and of different species, seem to be produced for no other purpose but to devour the pucerons. Some of these insects are so voracious, that, notwithstanding the extreme prolific powers of the pucerons, we have reason to be surprised that their species are not entirely annihilated. On every leaf inhabited by the puceron we find worms of different kinds. These worms feed not upon the leaves, but upon the pucerons, whom they devour with an almost incredible rapacity. Some of these worms are transformed into flies with two wings, others into flies with four wings, and others into beetles. While in the worm-state, one of these gluttonous insects will suck out the vitals of twenty pucerons in a quarter of an hour. Reaumur supplied a single worm with more than a hundred pucerons, every one of which it devoured in less than three hours.

Beside the general system of carnage produced by the necessity of one animal's feeding upon another, there are other sources of destruction, which originate from very different motives. Man is not the only animal who wages war with his own species. War among mankind, in certain accidental situations of society, may be productive, to particular nations or communities, of beneficial effects. But every advantage derived by war to one nation is acquired at the expence, and either the partial or the total ruin of another. If universal peace could be completely established, and if the earth were cultivated to the highest perfection, it is not probable that the multiplication of the human species would ever rise to such a degree as to exceed the quantity of provisions produced by agriculture, and by the breeding of domestic animals, necessary for their existence and happiness. But,

as long as men are actuated by ambition, by resentment, and by many other hostile passions, war and animosity, with all their train of blood-shed and calamity, will forever continue to harass and persecute the human kind. Let us, however, be humble. We cannot unfold the mysteries of Nature; but we may admire her operations, and submit, with a becoming resignation, to her irresistible decrees. The man, if such a man there be, whose strength of mind enables him to observe steadfastly this conduct, is the only real philosopher.

As formerly remarked, man is not the only animal that makes war with his own species. Quadrupeds, birds, fishes, insects, independently of their appetite for food, occasionally fight and kill each other. On this subject we shall confine ourselves to a few examples derived from the insect tribes.

A society or hive of bees consists of a female, of males, and of drones, or neuters. These three kinds continue, for some time, in the most perfect harmony, and mutually protect and assist each other. The neuters, or working bees, discover the strongest attachment and affection to the males, even when in their worm state. The neuters are armed with a deadly sting, of which the males are destitute. Both are equally produced by the same mother, and live in the same family. But, notwithstanding their temporary affection, there are times when the neuters cruelly massacre the males. Among the laws of polished republics, we find some which are extremely barbarous. The Lacedemonians were allowed to kill such of their children as were produced in a defective or maimed state, because they would become a burden upon the community. The laws of the Chinese permit actions equally inhuman. We perhaps know not all the reasons why the neuter bees treat the males with so much cruelty. There is a time, however, when the males become perfectly useless to the community; and it is not incurious to remark, that the general massacre never commences till

this period arrives. Whenever a stranger bee enters a hive, his temerity is uniformly punished with death. But mortal combats are not unfrequent between bees belonging to the same hive. These combats are most frequent in clear and warm weather. Sometimes two combatants come out of the hive closely fastened to each other. At other times the attack is made in the air. But, in whatever way the battle begins, both combatants uniformly come to the ground before it is terminated by the death of one of the parties. When they reach the ground, each individual, like a wrestler, endeavours to gain the most advantageous position for stinging his adversary to death. Sometimes, though rarely, the sting is left in the wound. If this were generally the case, every combat would prove fatal to two bees; for the victor could not long survive the loss of his sting. These battles sometimes continue near an hour before one of the flies is left expiring on the ground.

Beside these single combats, general actions are not unfrequent, especially in the swarming season. When two swarms, or colonies, happen to contend for the same habitation, a general and bloody engagement immediately ensues. These engagements often continue for hours, and never terminate without great havock on both sides. The sting is not the only weapon employed in war by bees. They are furnished with two strong fangs or teeth, with which they cruelly tear each other. Even in general engagements, all the combats are single. But, when the great slaughter of the males is committing, three or four neuters are not ashamed to attack a single fly.

Every wasp's nest, about the beginning of October, exhibits a singular and a cruel scene. At this season, the wasps cease to bring nourishment to their young. From affectionate mothers or nurses, they at once become barbarous stepmothers. They are worse; for they drag the young worms from their cells, and carry them out of the nest. Being thus

exposed to the weather, and deprived of nourishment, every one of them unavoidably perishes. This devastation is not like that of the honey-bees, confined to the male-worms. Here no worm, of whatever denomination or sex, escapes the general and undistinguishing massacre. Beside exposing the worms to the weather, the wasps kill them with their fangs. This fact seems to be a violation of parental affection, one of the strongest principles in animal nature. But the intentions of Nature, though they may often elude our researches, are never wrong. What appears to us cruel and unnatural in this instinctive devastation committed annually by the wasps, is perhaps an act of the greatest mercy and compassion. Wasps are not, like the honey-bees, endowed with the instinct of laying up a store of provisions for winter subsistence. If not prematurely destroyed by their parents, the young must necessarily die a more cruel and lingering death, occasioned by hunger. Hence this seemingly harsh conduct in the oeconomy of wasps, instead of affording an exception to the universal benevolence and wisdom of Nature, is, in reality, a merciful institution. Besides, as the multiplication of wasps is prodigious, and as they are a noxious race both to man and other animals, and especially to many tribes of insects, if their increase were not checked by such a dreadful carnage, their depredations, in a few years, would annihilate other species, break the chain of Nature, and even prove destructive to man and the larger animals.

The same instinctive slaughter, and probably for the same reasons, is made by the hornets. Towards the end of October, all the worms and nymphs are dragged out of the nest and killed. The neuters and males fall daily victims to the cold; so that, at the end of winter, a few fertile females only remain to continue the species.

According to the adopted plan, we shall finish this subject with some observations which may have a tendency to recon-

file our minds to a system so destructive to individuals of every species, that humanity, when not enlightened by a ray of philosophy, is apt to revolt, and to brand Nature with cruelty and oppression. Nature, it must be confessed, seems almost indifferent to individuals, who perish every moment in millions, without any apparent compunction. But, with regard to species of every description, her uniform and uninterrupted attention to the preservation and continuation of the great system of animation is conspicuous, and merits admiration. Life, it should appear, cannot be supported without the intervention of death. Through almost the whole of animated Nature, as we have seen, nothing but rapine, and the destruction of individuals, prevail. This destruction, however, has its use. Every animal, after death, administers life and happiness to a number of others. In many animals, the powers of digestion, and of assimilation, are confined to animal substances alone. If deprived of animal food, such species, it is evident, could not exist. The chief force of this observation, it is admitted, is applicable solely to the carnivorous tribes, strictly so denominated. But, from the facts formerly enumerated, and from the daily experience of every man, it is apparent, that, perhaps, no animal does or can exist totally independent of food that is or has been animated. Sheep, oxen, and all herbivorous animals, though not from choice, and even without consciousness, daily devour thousands of insects. This may be one reason why cattle of all kinds fatten so remarkably in rich pastures; for insects are always most numerous where the herbage is luxuriant. Nature is so profuse in her animated productions, that no food can be eat, and no fluid can be drunk, in which animal substances, either in a living or dead state, are not to be found.

To this reasoning it may be objected, Why has Nature established a system so cruel? why did she render it neces-

fary that one animal could not live without the destruction of another ? To such questions no answer can be either given or expected. No being; except the Supreme, can unfold this mystery. Perhaps it even exceeds the limits of possibility to establish such an extended system of animation upon any other foundation.. From the general benevolence of the great Creator, we are warranted to conclude that this is really the case. But it is fruitless to dwell upon subjects which are inscrutable, and far removed beyond the powers of human intellect. We shall therefore descend, and endeavour to point out some advantages which result from this mysterious institution of Nature.

On this branch of the subject, the reader will easily perceive that much order or connection is not to be expected.

The hostilities of animals, mankind not excepted, give rise to mutual improvement. Animals improve, and discover a superiority of parts, in proportion to the number of enemies they have to attack or evade. The weak, and consequently timid, are obliged to exert their utmost powers in inventing and practising every possible mode of escape. Pure instinct powerfully prompts; but much is learned by experience and observation. Rapacious animals, on the contrary, by frequent disappointment, are obliged to provide against the cunning and alertness of their prey. Herbivorous animals, as they have little difficulty in procuring food, are proportionally stupid ; but they would be still more stupid, if they had no enemies to annoy them. Man, if his attention and talents were not excited by the animosities of his own species, by the attacks of ferocious animals, and even by those of the insect tribes, would be an indolent, an incurious, a dirty, and an ignorant animal. Those of the human race, accordingly, who procure their food with little or no industry, as we learn from a multitude of travellers and voyagers, are perfectly indolent and brutishly stupid. Timid animals nev-

er use the arts of defence, or provide against danger, except from three causes, pure instinct, which is implanted in their natures, imitation, and experience. By experience, timid animals are taught the arts of evasion. Flight is instinctive ; but the modifications of it are acquired by imitation and experience.

Hostilities, in some instances, seem to arise, not from a natural antipathy of one species to another, but from a scarcity of food. The celebrated Captain Cook informs us, that, in Staten Island, birds of prey assemble promiscuously with penguins and other birds, without the one offering any injury, or the other discovering the smallest symptom of terror. In that Island, the rapacious birds, perhaps, find plenty of food from dead seals, sea-lions, and fishes.

A profusion of animal life seems to be the general intention of Nature. For this purpose, when not modified or restrained by the industry and intelligence of man, she uniformly covers the surface of the earth with trees and vegetables of every kind, which supply myriads of animated beings with food. But the greatest possible extention of life would still be wanting, if animals did not prey upon each other. If all animals were to live upon vegetables alone, many species, and millions of individuals, which now enjoy life and happiness, could have no existence ; for the productions of the earth would not be sufficient to support them. But, by making animals feed upon each other, the system of animation and of happiness is extended to the greatest possible degree. In this view, Nature, instead of being cruel and oppressive, is highly generous and beneficent.

To diminish the number of noxious animals, and to augment that of useful vegetables, has been the uniform scope of human industry. A few species of animals only are of immediate utility to man. These he either cultivates with care, or hunts for his prey. The ox, the sheep, the goat,

and other animals which are under his peculiar protection, he daily uses for food. This is not cruelty. He has a right to eat them: For, like Nature, though he occasionally destroys domestic animals, a timid and docile race of beings, by his culture and protection he gives life and happiness to millions, which, without his aid, could have no existence. The number of individuals, among animals of this description if they were not cherished and defended by man, would be extremely limited; for, by the mildness of their dispositions, the comparative weakness of their arms, and the universal and strong appetite for them by rapacious quadrupeds and birds of prey, though the species might, perhaps, be continued, the number of individuals would, of necessity, be very small.

There is a wonderful balance in the system of animal destruction. If the general profusion of the animated productions of Nature had no other check than the various periods to which their lives, when not extinguished by hostilities of one kind or another, are limited, the whole would soon be annihilated by an universal famine, and the earth, instead of every where teeming with animals, would, unless re-peopled by a new creation, exhibit nothing but a mute, a lifeless, and an inactive scene. If even a single species were permitted to multiply without disturbance, the food of other species would be exhausted, and, of course, a period would be put to their existence. The herbivorous and frugivorous races, if not restrained by the carnivorous, would soon increase to a hurtful degree. Carnivorous animals are the barriers fixed by Nature to noxious inundations of other kinds. The carnivorous tribes may be compared to the hoe and the pruning hook, which, by diminishing the number of plants when too close, or lopping off their luxuriancies, make the others grow to greater perfection. To those swarms of insects which cover the surface of the earth, are opposed an army of

birds, an active, a vigilant, and a voracious race. Hares, rabbits, mice, rats, are exposed to the depredations of carnivorous quadrupeds and birds. The larger cattle, as the ox, the deer, the sheep, &c. are not exempted from enemies : And man, by the superiority of his mental powers, checks the multiplication of the carnivorous tribes, and maintains the balance and empire of the animal system. Those species which are endowed with uncommon fertility have the greatest number of enemies. The caterpillar, the puceron, and insects in general, one of the most prolific tribes of animals, are attacked and devoured by numerous hostile bands. No species, however, is ever exhausted. The balance between gain and loss is perpetually preserved. The earth, the seas, the atmosphere, may be considered as an immense and variegated pasture. In this view, it is most judiciously cultivated and stocked by the numerous animated beings which it is destined to support. Every animal and every vegetable furnish subsistence to particular species. Thus, nothing of value is lost ; and every species is abundantly supplied with food.

That the general balance of animation is constantly preserved, we learn from daily experience. The reader, however, I presume, will not be displeased to have some examples of the modes employed by Nature to accomplish this effect suggested to him.

After an inundation of the Nile, the lower parts of Egypt are greatly infested with serpents, frogs, mice, and other vermin. At that period, the storks resort thither in immense multitudes, and devour the serpents, frogs, and mice, which, without this dreadful carnage, would be highly noxious to the inhabitants. Belon, a most ingenious and faithful French naturalist, remarks, that, in many places, the land could not be inhabited, if the storks did not destroy the amazing numbers of mice which frequently appear in Palestine, and other parts of the East bordering upon Egypt. The Egyptian vul-

ture, says Hasselquist, is of a singular benefit to that country. It eats up all the dung and off-falls in the towns, and the carcases of camels, horses, asses, &c. in the fields, which, if not quickly devoured, would, in that warm climate, by their putrefaction, be productive of disease and death to the inhabitants. Putrid carcases, in all countries, are both offensive to the nostrils and hurtful to health. But Nature, by various instruments, soon removes the evil. An animal no sooner dies, than, in a very short time, he is consumed by bears, wolves, foxes, dogs, and ravens. In situations where these animals dare not approach, as in the vicinity of towns and villages, a dead horse, in a few days, is devoured by myriads of maggots. In the uncultivated parts of America, serpents and snakes of different kinds abound. After it was discovered that swine greedily devoured serpents, hogs were uniformly kept by all new settlers. Caterpillars are destructive to the leaves and fruits of plants. Their numbers and varieties are immense. But their devastations are checked by many enemies. Without a profusion of caterpillars, most of the smaller birds, especially when young, could not be supported. By devouring the caterpillars, these birds preserve the fruits of the earth from total destruction. Mr. Bradley, in his general treatise of husbandry and gardening, has published a letter, in which the author opposes the common opinion, that birds, and particularly sparrows, do much mischief in our gardens and fields. The fact is admitted. But the great utility of these birds is overlooked : For this author proves, that they are much more useful than noxious. He shows, that a pair of sparrows, during the time they have their young to feed, destroy, every week, 3360 caterpillars. This calculation he founded upon actual observation. He discovered that the two parents carried to the nest 40 caterpillars in an hour. He then supposes, which is a moderate supposition, that the sparrows enter the nest only 12 hours

each day, which is a daily consumption of 480 caterpillars. This sum, multiplied by 7, or the days of the week, gives 3360 caterpillars extirpated weekly from a garden. The utility of these birds is not limited to this circumstance alone ; for they likewise feed their young with butterflies, and other winged insects, each of which, if not destroyed in this manner, would be the parent of several hundreds of caterpillars. Those butterflies and caterpillars which are covered with hair are rejected by some birds, who prefer flies of a smoother and smaller kind. But these hairy species, it should be considered, are the food of the worms which are transformed into those smaller flies that afford nourishment to the birds which reject the hairy caterpillars and butterflies.

Shell-fishes are extremely prolific, and so strongly fortified by Nature, that their increase, one should imagine, would soon augment to a degree that might be hurtful to other species. Their noxious multiplication, however, is checked by numberless enemies. But their most destructive enemy is the trochus, which is a kind of a sea-snail. This animal is furnished with a strong, muscular, hollow trunk, bordered at the extremity with a cartilage toothed like a saw. Against this instrument, which acts like an augre, no shell, however, hard or thick, is a sufficient defence. These animals, called *trochi*, fix themselves upon an oyster or a muscle, bore through the shell with their trunk, and devour their prey at their leisure. The animal attacked, if a bivalve, may open or shut its shell ; but no efforts of this kind can be of any avail ; for the trochus remains immovably fixed till it has completely sucked out the vitals of its prey. In this cruel occupation the trochus often continues for days, and even weeks, before the life of the animal attacked is fully extinguished. The operation of the trochus may be seen in the shells of many oysters, muscles, and other shell-fishes ; for their shells are often pierced with a number of circular holes.

The amazing size and strength of the whale, one should imagine, would secure it from the insults of every other animal. But, beside the annual depredations made by man upon the cetaceous tribes, they are often attacked and killed by the sword-fish. The snout of this comparatively small animal is armed with a long, hard, projection of bone, each edge of which is furnished with a number of strong, flat, and sharp points, or teeth, some of which, especially near the snout, are an inch and a half in length. With this instrument the sword-fish boldly attacks the whale. I have often had the pleasure, says Pere Labat*, of seeing their combats. The whale has no other defence but its tail, with which it endeavours to strike its antagonist. But, as the sword-fish is more active and nimble than the whale, he easily parries the blow by springing into the air, and renewing the attack with his saw-like instrument. Whenever he succeeds, the sea is dyed red with the blood issuing from the wound. The fury of the whale appears from the vehemence with which it lashes the waters, each stroke resounding like the report of a cannon.

Many small birds, and particularly the wren and the tit-mouse, may be seen, during the winter-season, pecking at the buds and branches of trees in our gardens. To these little animals Nature has entrusted the charge of preventing the noxious multiplication of those worms which feed upon fruits. Nature, as far as we are able to trace her operations, does nothing in vain, or without some valuable intention. No animals exist which are not useful, either by affording nourishment to, or preventing the hurtful increase of other species.

Upon the whole, every animated being that inhabits this globe seems to be destined by Nature, not for its own individual existence and happiness alone, but likewise for the ex-

* *Nouv. Voyage, tom. 6.* page 150.

istence and happiness of other animated beings. A circle of animation and of destruction goes perpetually round. This is the oeconomy of Nature. Different species of animals live by the mutual destruction of each other. Even among individual men, the strong too often oppress the weak ; but, on the other hand, the wise instruct the ignorant. These are the bonds of society, and the sources of improvement.

CHAPTER XV.

Of the Artifices of Animals.

IT will be recollect'd, that many instances of the dexterity and artifices employed by different animals in various parts of their manners and oeconomy, have been occasionally mentioned in several of the foregoing chapters. This circumstance, to avoid repetitions, will necessarily render the present chapter proportionally short.

The artifices practised by animals proceed from several motives, many of which are purely instinctive, and others are acquired by experience and imitation. Their arts, in general, are called forth and exerted by three great and important causes, the love of life, the desire of multiplying and continuing the species, and that strong attachment which every animal has to its offspring. These are the sources from which all the movements, all the dexterity, and all the sagacity of animals originate. The principle of self-preservation is instinctive, and strongly impressed upon the minds of all animated beings. It gives rise to innumerable arts of attack and defence, and not unfrequently to surprising exertions of sagacity and genius. The same remark is applicable to the desire of multiplication, and to parental affection. Upon this subject we shall, as usual, give some examples of animal artifice, which may both amuse and inform some readers.

When a bear, or other rapacious animal, attacks cattle, they instantly join and form a phalanx for mutual defence. In the same circumstances, horses rank upon lines, and beat off the enemy with their heels. Pontopidion tells us, that the small Norwegian horses, when attacked by bears, instead of striking with their hind-legs, rear, and, by quick and repeated strokes with their fore-feet, either kill the enemy, or

oblige him to retire. This curious, and generally successful defence, is frequently performed in the woods, while a traveller is sitting on the horse's back. It has often been remarked, that troops of wild horses, when sleeping either in plains or in the forest, have always one of their number awake, who acts as a sentinel, and gives notice of any approaching danger.

Margraaf informs us, that the monkeys in Brazil, while they are sleeping on the trees, have uniformly a sentinel to warn them of the approach of the tiger or other rapacious animals ; and that, if ever this sentinel is found sleeping, his companions instantly tear him in pieces for his neglect of duty. For the same purpose, when a troop of monkeys are committing depredations on the fruits of a garden, a sentinel is placed on an eminence, who, when any person appears, makes a certain chattering noise, which the rest understand to be a signal for retreat, and immediately fly off and make their escape.

The deer-kind are remarkable for the arts they employ in order to deceive the dogs. With this view the stag often returns twice or thrice upon his former steps. He endeavours to raise hinds or younger stags to follow him, and to draw off the dogs from the immediate object of their pursuit. If he succeeds in this attempt, he then flies off with redoubled speed, or springs off at a side, and lies down on his belly to conceal himself. When in this situation, if by any means his foot is recovered by the dogs, they pursue him with more advantage, because he is now considerably fatigued. Their ardour increases in proportion to his feebleness ; and the scent becomes stronger as he grows warm. From these circumstances the dogs augment their cries and their speed ; and, though the stag employs more arts of escape than formerly, as his swiftness is diminished, his doublings and artifices become gradually less effectual. No other

resource is now left him but to fly from the earth which he treads, and go into the waters, in order to cut off the scent from the dogs, when the huntsmen again endeavour to put them on the track of his foot. After taking to the water, the stag is so much exhausted that he is incapable of running much farther, and is soon *at bay*, or, in other words, turns and defends himself against the hounds. In this situation he often wounds the dogs, and even the huntsmen, by blows with his horns, till one of them cuts his hams to make him fall, and then puts a period to his life. The fallow-deer is more delicate, less savage, and approaches nearer to the domestic state than the stag. The males, during the rutting season, make a bellowing noise, but with a low and interrupted voice. They are not so furious as the stag. They never depart from their own country in quest of females; but they bravely fight for the possession of their mistresses. They associate in herds, which generally keep together. When great numbers are assembled in one park, they commonly form themselves into two distinct troops, which soon become hostile; because they are both ambitious of possessing the same part of the inclosure. Each of these troops has its own chief or leader, who always marches foremost, and he is uniformly the oldest and strongest of the flock. The others follow him; and the whole draw up in order of battle, to force the other troop, who observe the same conduct, from the best pasture. The regularity with which these combats are conducted is singular. They make regular attacks, fight with courage, and never think themselves vanquished by one check; for the battle is daily renewed till the weaker are completely defeated, and obliged to remain in the worst pasture. They love elevated and hilly countries. When hunted, they run not straight out, like the stag, but double, and endeavour to conceal themselves from the dogs by various artifices, and by substituting other animals in their

place. When fatigued and heated, however, they take the water, but never attempt to cross such large rivers as the stag. Thus, between the chase of the fallow-deer and of the stag, there is no material difference. Their sagacity and instincts, their shifts and doublings, are the same, only they are more frequently practised by the fallow-deer. As he runs not so far before the dogs, and is less enterprising, he has oftener occasion to change, to substitute another in his place, to double, return upon his former tracks, &c. which renders the hunting of the fallow-deer more subject to inconveniences than that of the stag.

The roe-deer is inferior to the stag and fallow-deer both in strength and stature; but he is endowed with more gracefulness, courage, and vivacity. His eyes are more brilliant and animated. His limbs are more nimble; his movements are quicker, and he bounds with equal vigour and agility. He is likewise more crafty, conceals himself with greater address, and derives superior resources from his instincts. Though he leaves behind him a stronger scent than the stag, which increases the ardour of the dogs, he knows how to evade their pursuit, by the rapidity with which he commences his flight, and by his numerous doublings. He delays not his arts of defence till his strength begins to fail him; for he no sooner perceives that the first efforts of a rapid flight have been unsuccessful, than he repeatedly returns upon his former steps; and, after confounding, by these opposite motions, the direction he has taken, after intermixing the present with the past emanations of his body, he, by a great bound, rises from the earth, and, retiring to a side, lies down flat on his belly. In this immoveable situation, he often allows the whole pack of his deceived enemies to pass very near him. The roe-deer differs from the stag in disposition, manners, and in almost every natural habit. Instead of associating in herds, they live in separate families. The two

parents and the young go together, and never mingle with strangers. They are constant in their amours, and never unfaithful like the stag. The females commonly produce two fawns, the one a male and the other a female. These young animals, who are brought up and nourished together, acquire a mutual affection so strong, that they never depart from each other. This attachment is something more than love ; for, though always in company, they feel the rut but once a year, and it continues only fifteen days. At this period the father drives off the fawns, as if he intended that they should yield their place to those which are to succeed, in order to form new families for themselves. After the rutting season, however, is past, the fawns return to their mother, and continue with her some time longer ; after which they separate forever, and remove to a distance from the place of their nativity. When about to bring forth, the female separates from the male ; and, to avoid the wolf, her most dangerous enemy, conceals herself in the deepest recesses of the forest. In a week or two the fawns are able to follow her. When threatened with danger, she hides them in a close thicket ; and, so strong is her parental affection, that, in order to preserve her offspring from destruction, she presents herself to be chased.

Hares possess not, like rabbits, the art of digging retreats in the earth. But they neither want instinct sufficient for their own preservation, nor sagacity for escaping their enemies. They form seats or nests on the surface of the ground, where they watch, with the most vigilant attention, the approach of any danger. In order to deceive, they conceal themselves between clods of the same colour with that of their own hair. When pursued, they first run with rapidity, and then double, or return upon their former steps. From the place of starting, the females run not so far as the males ; but they double more frequently. Hares hunted in the place

where they were brought forth, seldom remove to a great distance from it, but return to their form ; and, when chased two days successively, on the second day they perform the same doublings they had practised the day before. When hares run straight out to a great distance, it is a proof that they are strangers. Male hares, especially during the most remarkable period of rutting, which is in the months of January, February, and March, sometimes perform journeys of several miles in quest of mates ; but, as soon as they are started by dogs, they fly back to the place of their nativity.

‘I have seen a hare,’ Fouilloux remarks, ‘so sagacious, that, after hearing the hunter’s horn, he started from his form, and, though at the distance of a quarter of a league, went to swim in a pool, and lay down on the rushes in the middle of it, without being chased by the dogs. I have seen a hare after running two hours before the dogs, push another from his seat, and take possession of it. I have seen others swim over two or three ponds, the narrowest of which was eighty paces broad. I have seen others, after a two hours chace, run into a sheep-fold and lie down among them. I have seen others, when hard pushed, run in among a flock of sheep, and would not leave them. I have seen others, after hearing the noise of the hounds, conceal themselves in the earth. I have seen others run up one side of a hedge and return by the other, when there was nothing else between them and the dogs. I have seen others, after running half an hour, mount an old wall, six feet high, and clap down in a hole covered with ivy. Lastly, I have seen others swim over a river, of about eighty paces broad, oftener than twice, in the length of two hundred paces.’

The fox has, in all ages and nations, been celebrated for craftiness and address. Acute and circumspect, sagacious and prudent, he diversifies his conduct, and always reserves some art for unforeseen accidents. Though nimbler than

the wolf, he trusts not entirely to the swiftness of his course. He knows how to ensure safety, by providing himself with an asylum, to which he retires when danger appears. He is not a vagabond, but lives in a settled habitation and in a domestic state. The choice of situation, the art of making and rendering a house commodious, and of concealing the avenues which lead to it, imply a superior degree of sentiment and reflection. The fox possesses these qualities, and employs them with dexterity and advantage. He takes up his abode on the border of a wood, and in the neighbourhood of cottages. Here he listens to the crowing of the cocks and the noise of the poultry. He scents them at a distance. He chooses his time with great judgment and discretion. He conceals both his route and his design. He moves forward with caution, sometimes even trailing his body, and seldom makes a fruitless expedition. When he leaps the wall, or gets in underneath it, he ravages the court-yard, puts all the fowls to death, and then retires quietly with his prey, which he either conceals under the herbage, or carries off to his kennel. In a short time he returns for another, which he carries off and hides in the same manner, but in a different place. In this manner he proceeds, till the light of the sun, or some movements perceived in the house, admonish him that it is time to retire to his den. He does much mischief to the bird-catchers. Early in the morning he visits their nets and their bird-lime, and carries off successively all the birds that happen to be entangled. The young hares he hunts in the plains, seizes old ones in their seats, digs out the rabbits in the warrens, finds out the nests of partridges, quails, &c. seizes the mother on the eggs, and destroys a prodigious number of game. Dogs of all kinds spontaneously hunt the fox. Though his odour be strong, they often prefer him to the stag or the hare. When pursued he runs to his hole ; and it is not uncommon to send in terriers to

detain him till the hunters remove the earth above, and either kill or seize him alive. The most certain method, however, of destroying a fox is to begin with shutting up the hole, to station a man with a gun near the entrance, and then to search about with the dogs. When they fall in with him, he immediately makes for his hole. But, when he comes up to it, he is met with a discharge from the gun. If the shot misses him, he flies off with full speed, takes a wide circuit, and returns again to the hole, where he is fired upon a second time ; but, when he discovers that the entrance is shut, he darts away straight forward, with the intention of never revisiting his former habitation. He is next pursued by the hounds, whom he seldom fails to fatigue ; because, with much cunning, he passes through the thickest part of the forest, or places of the most difficult access, where the dogs are hardly able to follow him ; and, when he takes to the plains, he runs straight out, without either stopping or doubling. But the most effectual way of destroying foxes is to lay snares baited with live pigeons, fowls, &c. The fox is an exceedingly voracious animal. Beside all kinds of flesh and fishes, he devours, with equal avidity, eggs, milk, cheese, fruits, and particularly grapes. He is so extremely fond of honey, that he attacks the nests of wild bees. They at first put him to flight by numberless stings ; but he retires for the sole purpose of rolling himself on the ground and of crushing the bees. He returns to the charge so often, that he obliges them to abandon the hive, which he soon uncovers, and devours both the honey and the wax. Some time before the female brings forth, she retires, and seldom leaves her hole, where she prepares a bed for her young. When she perceives that her retreat is discovered, and that her young have been disturbed, she carries them off, one by one, into a new habitation. The fox sleeps in a round form, like the dog ; but, when he only reposes himself, he lies on his

belly with his hind-legs extended. It is in this situation that he eyes the birds on the hedges and trees. The birds have such an antipathy against him, that they no sooner perceive him than they send forth shrill cries to advertise their neighbours of the enemy's approach. The jays and blackbirds, in particular, follow the fox from tree to tree, sometimes two or three hundred paces, often repeating the watch-cries. The Count de Buffon kept two young foxes, which, when at liberty, attacked the poultry ; but, after, they were chained, they never attempted to touch a single fowl. A living hen was fixed near them for whole nights ; and, though destitute of victuals for many hours, in spite of hunger and of opportunity, they never forgot that they were chained, and gave the hen no disturbance.

In Kamtschatka, the animals called *gluttons* employ a singular stratagem for killing the fallow-deer. They climb up a tree, and carry with them a quantity of that species of moss of which the deer are very fond. When a deer approaches near the tree, the glutton throws down the moss. If the deer stops to eat the moss, the glutton instantly darts down upon its back and, after fixing himself firmly between the horns, tears out its eyes, which torments the animal to such a degree, that, whether to put an end to its torments, or to get rid of its cruel enemy, it strikes its head against the trees till it falls down dead. The glutton divides the flesh of the deer into convenient portions, and conceals them in the earth to serve for future provisions. The gluttons on the river Lena kill horses in the same manner*.

There are several species of rats in Kamtschatka. The most remarkable kind is called *tegulchitch* by the natives. These rats make neat and spacious nests under ground. They are lined with turf, and divided into different apartments, in which the rats deposit stores of provisions for supporting them during the winter. It is worthy of remark, that the

* *Gazette Literaire*, vol. I. page 481.

rats of this country never touch the provisions laid up for winter, except when they cannot procure nourishment anywhere else. These rats, like the Tartars, change their habitations. Sometimes they totally abandon Kamtschatka for several years, and their retreat greatly alarms the inhabitants, which they consider as a presage of a rainy season, and of a bad year for hunting. The return of these animals is, of course, looked upon as a good omen. Whenever they appear, the happy news is soon spread over all parts of the country. They always take their departure in the spring, when they assemble in prodigious numbers, and traverse rivers, lakes, and even arms of the sea. After they have made a long voyage, they frequently lie motionless on the shore, as if they were dead. When they recover their strength they recommence their march. The inhabitants of Kamtschatka are very solicitous for the preservation of these animals. They never do the rats any injury, but give them every assistance when they lie weakened and extended on the ground. They generally return to Kamtschatka about the month of October; and they are sometimes met with in such prodigious numbers that travellers are obliged to stop two hours till the whole troop passes. The track of ground they travel in a single summer is not less wonderful than the regularity they observe in their march, and that instinctive impulse which enables them to foresee, with certainty, the changes of times and of seasons.

With regard to *Birds*, their artifices are not less numerous nor less surprising than those of quadrupeds. The eagle and hawk kinds are remarkable for the sharpness of their sight and the arts they employ in catching their prey. Their movements are rapid or slow, according to their intentions, and the situation of the animals they wish to devour. Rapacious birds uniformly endeavour to rise higher in the air than their prey, that they may have an opportunity of darting forcibly down upon it with their pounces. To counter-

at these artifices, Nature has endowed the smaller and more innocent species of birds with many arts of defence. When a hawk appears, the small birds, if they find it convenient, conceal themselves in the hedges of brush-wood. When deprived of this opportunity, they often, in great numbers, seem to follow the hawk, and to expose themselves unnecessarily to danger, while, in fact, by their numbers, their perpetual changes or direction, and their uniform endeavours to rise above him, they perplex the hawk to such a degree, that he is unable to fix upon a single object ; and, after exerting all his art and address, he is frequently obliged to relinquish the pursuit. When in the extremity of danger, and after employing every other artifice in vain, small birds have been often known to fly to men for protection. This is a plain indication that these animals, though they in general avoid the human race, are by no means so much afraid of man as of rapacious birds.

The ravens often frequent the sea-shores in quest of food. When they find their inability to break the shells of muscles, &c. to accomplish this purpose they use a very ingenious stratagem : They carry a muscle, or other shell-fish, high up in the air, and then dash it down upon a rock, by which means the shell is broken, and they obtain the end they had in view.

The wood-pecker is furnished with a very long and voluminous tongue. It feeds upon ants and other small insects. Nature has endowed this bird with a singular instinct. It knows how to procure food without seeing its prey. It attaches itself to the trunks of branches of decayed trees ; and, wherever it perceives a hole or crevice, it darts in its long tongue, and brings it out loaded with insects of different kinds. This operation is certainly instinctive ; but the instinct is assisted by the instruction of the parents ; for the young are no sooner able to fly, than the parents, by the force of example,

teach them to resort to trees, and to insert their tongues indiscriminately into every hole or fissure.

Of the oeconomy of *Fishes*, as formerly remarked, our knowledge is extremely limited. But, as the ocean exhibits a perpetual and a general scene of attack and defence, the arts of assault and of evasion must, of course, be exceedingly various. For the preservation of some species of fishes, Nature has armed them with strong and sharp pikes. Others, as the perch-kind, are defended with strong bony rays in their fins. Others, as the univalve shell-fish, retire into their shells upon the approach of danger. The bivalves and multivalves, when attacked, instantly shut their shells, which, in general, is a sufficient protection to them. Some univalves, as the limpet-kind, attach themselves so firmly, by excluding the air, to rocks and stones, that, unless quickly surprised, no force inferior to that of breaking the shell can remove them. The flying-fish, when pursued, darts out of the water, and takes refuge in the air, in which it is for some time supported by the operation of its large and pliable fins. The torpedo is furnished with a remarkable apparatus for self-preservation : It repels every hostile attempt by an electrical stroke, which confounds and intimidates its enemies. Several fishes, and particularly the salmon kind, when about to generate, leave the ocean, ascend the rivers, deposit their eggs in the sand, and, after making a proper *nidus* for their future progeny, return to the ocean from whence they came. Others, as the herring-kind, though they seldom go up rivers, assemble in myriads from all quarters, and approach the shores, or ascend arms of the sea, for the purpose of propagating the species, and cherishing their offspring. When that operation is performed, they leave the coasts and disperse in the ocean, till the same instinctive impulse forces them to observe a similar conduct next season. This migration of salmons, herrings, and many other fishes, from the ocean to the rivers or shores, is of infinite advantage

to mankind. They supply us occasionally, and in some countries, as Great-Britain and particularly Scotland, with abundance of nourishing and luxurious food ; and, if our fisheries were once put upon a proper footing, they would soon constitute one of the most powerful incentives to industry, and become a great and important source of national strength and prosperity.

The *insect* tribes, though comparatively diminutive, are not deficient in artifice and address. With much art the spider spins his web. It serves him the double purpose of an habitation, and of a machine for catching his food. With incredible patience and perseverance he lies in the center of his web for days, and sometimes for weeks, before an ill-fated fly happens to be entangled. One species of spider, which is small, of a blackish colour, and frequents cottages or out-houses, I have known to live during the whole winter months without almost the possibility of receiving any nourishment ; for, during that period, not a fly of any kind could be discovered in the apartment. If they had been fixed in a torpid state, like some other animals, the wonder of their surviving the want of food so long would not have been so great. But in the severest weather, and through the whole course of the winter, they were perfectly active and lively. Neither did they seem to be in the least emaciated.

The *formico-leo*, or ant-lion, is a small insect, somewhat resembling a wood-louse, but larger. Its head is flat, and armed with two fine moveable crotchetts or pincers. It has six legs, and its body, which terminates in a point, is composed of a number of membranous rings. In the sand, or in finely pulverised earth, this animal digs a hole in the form of a funnel, at the bottom of which it lies in ambush for its prey. As it always walks backward, it cannot pursue any insect. To supply this defect, it lays a snare for them, especially for the ant, which is its favourite food. It generally lies concealed under the sand in the bottom of its funnel or trap, and sel-

dom exhibits more than the top of its head. In digging a funnel, the formica-leo begins with tracing a circular furrow in the sand, the circumference of which determines the size of the funnel, which is often an inch deep. After the first furrow is made, the animal traces a second, which is always concentric with the first. It throws out the sand, as with a shovel, from the successive furrows or circles, by means of its square flat head and one of its fore-legs. It proceeds in this manner till it has completed its funnel, which it does with surprising promptitude and address. At the bottom of this artful snare it lies concealed and immovable. When an ant happens to make too near an approach to the margin of the funnel, the sides of which are very steep, the fine sand gives way, and the unwary animal tumbles down to the bottom. The formica-leo instantly kills the ant, buries it under the sand, and sucks out its vitals. It afterwards pushes out the empty skin, repairs the disorder introduced into its snare, and again lies in ambush for a fresh prey.

We formerly took some notice of that species of spider which carries her eggs in a bag attached to her belly. A spider of this kind was thrown into the funnel of a formica-leo. The latter instantly seized the bag of eggs, and endeavoured to drag it under the sand. The spider from a strong love of offspring, allowed its own body to be carried along with the bag. But the slender silk by which it was fixed to the animal's belly broke, and a separation took place. The spider immediately seized the bag with her pincers, and exerted all her efforts to regain the object of her affections. But these efforts were ineffectual ; for the formica-leo gradually sunk the bag deeper and deeper in the sand. The spider, however, rather than quit her hold, allowed herself to be buried alive. In a short time, the observer removed the sand, and took out the spider. She was perfectly unhurt ; for the formica-leo had not made any attack upon her. But, so

strong was her attachment to her eggs, that, though frequently touched with a twig, she would not relinquish the place which contained them*.

When arrived at its full growth, the formica-leo gives up the business of an ensnaring hunter. He deserts his former habitation, and crawls about for some time on the surface of the earth. He at last retires under the ground, spins a round silken pod, and is soon transformed into a fly.

* Ouvres de Bonnet, vol. 4, page 295. 8vo edit. Amsterdam 1769.

CHAPTER XVI.

Of the Society of Animals.

THE associating principle, from which so many advantages are derived, is not confined to the human species, but extends, in some instances, to every class of animals.

It is remarked by Buffon, and some other authors, that the state of Nature, which had long occupied the attention and researches of philosophers, was rejected by them after the discovery was made. In the estimation of the authors alluded to, the savage state is the state of Nature. The first natural condition of mankind is the union of a male and a female. These produce a family, who, from necessity, or, in other words, from parental and filial affection, continue together, and assist each other in procuring food and shelter. This family, like most families in established civil societies, feel their own weakness, and their inability to supply their wants without more powerful resources than their feeble exertions. When this wandering and defenceless family accidentally meet with another family in the same condition, Nature, it is said, teaches them to unite for mutual support and protection. The association of two families may be considered as the first formation of a tribe or nation. When a number of tribes happen to unite, they only become a larger or more numerous nation. A single pair, it is true, if placed in a situation where plenty of food could be procured without much labour, might, in a succession of ages, produce any indefinite number. This is precisely the situation in which Moses has placed our first parents. He has added another circumstance highly favourable to a speedy population. Instead of the present brevity of human life, he informs us, that

men, in the first periods of the world, lived and propagated several hundred years.

In countries thinly peopled with savages, it is extremely probable, that societies are formed by the gradual union of families and tribes. The increase of power arising from mutual assistance, and a thousand other comfortable circumstances, soon contribute to cement more firmly the associated members. Some of the arts of life, beside that of hunting, are occasionally discovered either by accident or by the ingenuity of individuals. In this manner, gradual advances are made from the savage to the civilized condition of mankind. This is a very short view of the origin of society, which has been adopted by most authors both ancient and modern, though many of them have derived the associating principle from very different, and even from opposite causes, which it is no part of our plan either to enumerate or refute. Some writers, as Aristotle, and a few moderns, implicit followers of his opinions, deny that man is naturally a gregarious or associating animal. To render this notion consistent with the actual and universal state of the human race, these authors have had recourse to puerile conceits, and to questionable facts, which it would be fruitless to relate. Other writers, possessed of greater judgment and discernment, and less warped with vanity and hypothetical phantoms, have derived the origin of society from its real and only source, Nature herself.

That the associating principle is instinctive hardly requires a proof. An appeal to the feelings of any human being, and to the universal condition of mankind, is sufficient. These feelings, it may be said, are acquired by education and habit. By these causes, it is true, our social feelings are strengthened and confirmed ; but their origin is coeval with the existence of the first human mind. Let any man attend to the eyes, the features, and the gestures of a child upon the breast,

when another child is presented to it ; both instantly, previous to the possibility of instruction or habit, exhibit the most evident expressions of joy. Their eyes sparkle, their features and gestures demonstrate, in the most unequivocal manner, a mutual attachment, and a strong desire of approaching each other, not with a hostile intention, but with an ardent affection, which, in that pure and uncontaminated state of our being, does honour to human nature. When farther advanced, children who are strangers to each other, though their social appetite is equally strong, discover a mutual shyness of approach. This shyness or modesty, however, is soon conquered by the more powerful instinct of association. They daily mingle and sport together. Their natural affections, which, at that period, are strong, and unbiassed by those selfish and vicious motives which too often conceal and thwart the intentions of Nature, create warm friendships that frequently continue during their lives, and produce the most beneficial and cordial effects. When we thus see with our eyes, that the associating principle appears at a period much more early than many of our other instincts, who will listen to those writers who choose to deny that man is, naturally, an associating or gregarious animal ?

With regard to the advantages we derive from association, a volume would not be sufficient to enumerate them. Man, from the comparatively great number of instincts with which his mind is endowed, necessarily possesses a portion of the reasoning faculty highly superior to that of any other animal. He alone enjoys the power of communicating and expressing his ideas by articulate and artificial language. This inestimable prerogative is, perhaps, one of the greatest secondary bonds of society, and the greatest source of improvement to the human intellect. Without artificial language, though Nature has bestowed on every animal a mode of expressing its wants and desires, its pleasures and pains, what an humili-

inating figure would the human species exhibit, even upon the supposition that they did associate? But, when language and association are conjoined, the human intellect, in the progress of time, arrives at a high degree of perfection. Society gives rise to virtue, honour, government, subordination, arts, science, order, happiness. All the individuals of a community conduct themselves upon a regulated system. Under the influence of established laws, kings and magistrates, by the exercise of legal authority, encourage virtue, repress vice, and diffuse, through the extent of their jurisdictions, the happy effects of their administration. In society, as in a fertile climate, human talents germinate and are expanded; the mechanical and liberal arts flourish; poets, orators, historians, philosophers, lawyers, physicians, and theologians, are produced. These truths are pleasant; and it were to be wished that no evils accompanied them. But, through the whole extent of Nature, it should appear, from our limited views, that good and evil, pleasure and pain, are necessary and perpetual concomitants.

The advantages of society are immense and invaluable. But the inconveniences, hardships, injustice, oppressions, and cruelties, which too often originate from it are great and lamentable. Even under the mildest and best regulated governments, animosities, jealousies, avarice, fraud, and chicane, are unfortunately never removed from our observation. In absolute monarchies, and particularly in despotic governments, the scenes of private and of general calamity and distress are often too dreadful to be described. Notwithstanding all these disadvantages, however, any government is preferable to anarchy; and the comforts, pleasures, and improvements, we receive from associating with each other, overbalance all the evils to which society gives rise.

From an attentive observation of the manners and oeconomy of animals, society has been distinguished into two kinds,

which have been called *proper*, and *improper*. 1. *Proper Societies*, comprehend all those animals who not only live together in numbers, but carry on certain operations which have a direct tendency to promote the welfare and happiness of the community. 2. *Improper Societies*, include all those animals who herd together, and love the company of each other, without carrying on any common operations.

1. *Proper Societies*.—It is almost needless to remark that man holds the first rank in animal associations of this kind. If men did not assist each other, no operation of any magnitude, or which could show any great superiority of talents above those of the brute creation, could possibly be effected. A single family, or even a few families united, like other carnivorous animals, might hunt their prey, and procure a sufficient quantity of food. They might like the bear, lodge in the cavities of trees; they might occupy natural caves in the rocks; they might even build huts with branches of trees and with turf, and cement these gross materials with clay. This lowest and most abject view of human nature is not exaggerated. It were to be wished that this grovelling condition of mankind were fictitious, and that, in many regions of the globe, it did not, at this moment, exist. These operations of men, when only acquainted with the mere rudiments of society, indicate parts little superior to those of the brutes. Man, even in his most uninformed state, possesses the instincts, or the germs, of every species of knowledge and of genius. But they must be cherished, expanded, and brought gradually to perfection. It is by numerous and regularly established societies alone that such glorious exhibitions of human intellect can be produced. What is the hut of a savage when compared to the palace of a prince? or what his canoe when compared to a first rate ship of war?

Next to the intelligence exhibited in human society, that of the beavers is the most conspicuous. Their operations in

preparing, fashioning, and transporting, the heavy materials for building their winter habitations, as formerly remarked*, are truly astonishing ; and, when we read their history, we are apt to think that we are perusing the history of man in a period of society not inconsiderably advanced. It is only by the united strength, and co-operation of numbers, that the beavers could be enabled to produce such wonderful effects ; for, in a solitary state, as they at present appear in some northern parts of Europe, the beavers, like solitary savages, are timid and stupid animals. They neither associate, nor attempt to construct villages, but content themselves with digging holes in the earth. Like men under the oppression of despotic governments, the spirit of the European beavers is depressed, and their genius is extinguished by terror, and by a perpetual and necessary attention to individual safety. The northern parts of Europe are now so populous, and the animals there are so perpetually hunted for the sake of their furs, that they have no opportunity of associating ; of course, those wonderful remarks of their sagacity, which they exhibit in the remote and uninhabited regions of North America, are no longer to be found. The society of beavers is a society of peace and of affection. They never quarrel or injure one another, but live together in different numbers, according to the dimensions of particular cabins, in the most perfect harmony. The principle of their union is neither monarchical nor despotic. For the inhabitants of the different cabins, as well as those of the whole village, seem to acknowledge no chief or leader whatever. Their association presents to our observation a model of a pure and perfect republic, the only basis of which is mutual and unequivocal attachment. They have no law but the law of love and of parental affection. Humanity prompts us to wish that it were possible to establish republics of this kind among mankind.

* See above, page 313, &c.

But the dispositions of men have little affinity to those of the beavers.

The hampster, or German marmot, and some other quadrupeds of this kind, live in society, and assist each other in digging and rendering commodious their subterraneous habitations. The operations of the marmots have already been described ; and the nature of their society, as they continue during the winter in a torpid state, is either less known, or does not excite so much admiration as that of the beavers.

Pairing birds, in some measure, may be considered as forming proper societies ; because, in general, the males and females mutually assist each other in building nests and feeding their young. But this society, except in the eagle tribes, commonly continues no longer than their mutual offspring are fully able to provide for themselves. None of the feathered tribes, as far as we know, unite in bodies, in order to carry on any operation common to the whole.

Neither do we learn from history that fishes ever associate for the purpose of executing any common operation. Many of them, as herrings, salmons, &c. assemble in multitudes at particular seasons of the year ; but this association, to which they are impelled by instinct, has no common object ; for each individual is stimulated to act in this manner by its own motives, and no general effect is produced by mutual exertions.

In proper societies, each individual not only attends to his own preservation and welfare, but all the members co-operate in certain laborious offices which produce many common advantages that could not otherwise be procured. In some societies, the general principle of association and of mutual labour is purely instinctive, though, in many cases, individuals learn, by observation and experience, to modify or accommodate this general principle according to particular accidents or circumstances ; some examples of which have already been given in the chapter upon instinct.

The insect tribes furnish many instances of proper societies. The honey-bees not only labour in common with astonishing assiduity and art, but their whole attention and affections seem to centre in the person of the queen or sovereign of the hive. She is the basis of their association and of all their operations. When she dies by any accident, the whole community are instantly in disorder. All their labours cease. No new cells are constructed. Neither honey nor wax are collected. Nothing but perfect anarchy prevails, till a new queen or female is obtained. The government or society of bees is more of a monarchical than of a republican nature. The whole members of the state seem to respect and to be directed by a single female. This fact affords a strong instance of the force and wisdom of Nature. The female alone is the mother of the whole hive, however numerous. Without her the species could not be continued. Nature, therefore, has endowed the rest of the hive with a wonderful affection to their common parent. For the reception of her eggs Nature impels them to construct cells, and to lay up stores of provisions for winter subsistence. These operations proceed from pure instinctive impulses. But every instinct necessarily supposes a degree of intellect, a substratum to be acted upon, otherwise no impulse could be felt, and of course, no action nor mark of intelligence could possibly be produced.

That the intelligence, the government, and the sagacity of bees, have been frequently exaggerated, and as frequently misunderstood, no real philosopher, or natural historian, will pretend to deny. But the late ingenious Count de Buffon, through the whole of his great work, betrays the strongest inclination to deny that brutes, even those which are esteemed to be the most sagacious, as the dog, the elephant, &c. not to mention the inferior tribes, as birds, fishes, and insects, are endowed with the smallest portion of mind or intellect,

but that all their movements, their expressions, their desires, their arts, are solely the results of mechanical impulses. The Count is peculiarly severe in his declamations against the sagacity of the honey-bees, and the celebrators of their oeconomy and manners. ‘The genius of solitary bees,’ he remarks, ‘is vastly inferior to that of the gregarious species;’ and the talents of those which associate in small troops ‘are less conspicuous than of those that assemble in numerous bodies. Is not this alone sufficient to convince us, that ‘the seeming genius of bees is nothing but a result of *pure mechanism*, a combination of movements proportioned to numbers, an effect which appears to be complicated, only because it depends on thousands of individuals? It must, therefore, be admitted, that bees, taken separately, have less genius than the dog, the monkey, and most other animals:’ It will likewise be admitted, that they have less docility, less attachment, and less sentiment; and that they possess fewer qualities relative to those of the human species:’ Hence we ought to acknowledge, that their apparent intelligence proceeds solely from the *multitude united*. This union, however, presupposes not intellectual powers; for they unite not from moral views: They find themselves together without their consent. This society, therefore, is a physical assemblage ordained by Nature, and has no dependence on knowledge or reasoning. The mother bee produces at one time, and in the same place, ten thousand individuals, which, though they were much more stupid than I have supposed them, would be obliged, solely for the preservation of their existence, to arrange themselves into some order. As they all act against each other with equal forces, supposing their first movements to produce pain, they would soon learn to diminish this pain, or, in other words, to afford mutual assistance: They, of course, would

‘ exhibit an air of intelligence, and of concurring in the accomplishment of the same end. A superficial observer would instantly ascribe to them views and talents which they by no means possess: He would explain every action: Every operation would have its particular motive, and prodigies of reason would arise without number; for ten thousand individuals produced at one time, and obliged to live together, must all act in the very same manner; and, if endowed with feeling, they must acquire the same habits, assume that arrangement which is the least painful, or the most easy to themselves, labour in their hive, *return* after leaving it, &c. Hence the *origin* of the many wonderful talents ascribed to bees, such as their architecture, their geometry, their order, their foresight, their patriotism, and, in a word, their republic, the whole of which, as I have proved, has no existence but in the imagination of the observer*.’

That this mode of reasoning should have been seriously adopted by so great a literary character as that of the Count de Buffon, is truly astonishing. The substance of the argument is, that ten thousand bees, or other gregarious insects, when brought into existence at the same time, and in the same place, must necessarily by the inconvenience or pain arising from mutual pressure, assume an arrangement, and construct commodious and artful habitations for the whole community. I hate polemical argumentation; and philosophical absurdities are the most difficult to refute. If ten thousand butterflies, or any other flies, whose instinctive or mental powers differed from those of the bee, should be brought forth at the same time, and in the same place, which might be easily effected by collecting their chrysalids, would these animals, from the inconveniences or pain they might suffer by being crowded together, assume a proper arrange-

* Translation, vol. 3, page 285.

ment, and build habitations suited to their mutual comfort and preservation ? No. If not allowed to escape from their present situation, they would suffocate each other ; and, if any of them were permitted to get out of their prison, instead of returning, like the bees, they would avoid it with as much horror as a person who had made his escape from the Black Hole of Calcutta. No declamatory reasoning, however specious, will ever change the nature of truth. Without some portion of intellect, or what is synonymous, of mental powers, how should the different kinds of bees in the same hive be induced to perform so many different operations ? While some are busily employed at home in the construction of cells, others are equally industrious in the fields collecting materials for carrying on the work. They are no sooner relieved from their load by their companions and fellow-labourers in the hive, than they again repair to the fields, and, with persevering industry, fly from flower to flower till they have amassed another load of materials, which they immediately transport to the hive. In this laborious office they persist for many hours every day when the weather permits. Will any man pretend to assert, that these, and many similar operations performed by bees, are the results of mechanical impulses* ? Are bees, when collecting honey, and the farina of flowers, at great distances from the hive, compelled by the mechanical pressure of multitudes, to assume a certain arrangement, and all of them to act in the same manner ? Can any animal be possessed of more liberty, or be more free from mechanical restraint than a bee while roaming at large in the fields ? Besides, what should force a bee, while wallowing in luxury, to return so repeatedly to the hive with no other view than to feed its companions, or to furnish them with materials for their work ? Here every idea of mechanical impulse is utterly excluded. That bees,

* For several curious operations of bees, which it will be difficult to reconcile with any principles of mechanism, the reader may consult page 336, &c.

as well as other animals, are actuated by motives, or impulses, it is willingly allowed. But these are not mechanical impulses. They are the wise and irresistible impulses of Nature upon their minds. If bees did not associate, and mutually assist one another in their various operations, the species would soon be annihilated. Not one of them, it is probable, would survive the first winter. But Nature ever solicitous for the preservation of her productions, has endowed their minds with an associating principle, and with instincts which stimulate them to perform all those wonderful operations that are necessary for the existence of individuals, and the continuation of the species.

What are called the *common* caterpillars afford an instance of proper association. About the middle of summer, a butterfly deposits from three to four hundred eggs on the leaf of a tree, from each of which, in a few days, a young caterpillar proceeds. They are no sooner hatched than they begin to form a common habitation. They spin silken threads, which they attach to one edge of the leaf, and extend them to the other. By this operation they make the two edges of the leaf approach each other, and form a cavity resembling a hammock. In a short time, the concave leaf is completely roofed with a covering of silk. Under this tent the animals live together in mutual friendship and harmony. When not disposed to eat or to spin, they retire to their tent. It requires several of these habitations to contain the whole. According as the animals increase in size, the number of their tents is augmented. But these are only temporary and partial lodgements, constructed for mutual convenience, till the caterpillars are in a condition to build one more spacious, and which will be sufficient to contain the whole. After gnawing one half of the substance of such leaves as happen to be near the end of some twig or small branch, they begin their great work. In constructing this new edifice or nest,

the caterpillars encrust a considerable part of the twig with white silk. In the same manner, they cover two or three of such leaves as are nearest to the termination of the twig. They then spin silken coverings of greater dimensions, in which they inclose the two or three leaves together with the twig. The nest is now so spacious that it is able to contain the whole community, every individual of which is employed in the common labour. These nests are too frequently seen, in autumn, upon the fruit-trees of our gardens. They are still more exposed to observation in winter, when the leaves, which formerly concealed many of them, are fallen. They consist of large bundles of white silk and withered leaves, without any regular or constant form. Some of them are flat, and others roundish ; but none of them are destitute of angles. By different plain coverings extended from the opposite sides of the leaves and of the twig, the internal part of the nest is divided into a number of different apartments. To each of these apartments, which seem to be very irregular, there are passages by which the caterpillars can either go out in quest of food, or retire in the evening, or during rainy weather. The silken coverings, by repeated layers, become at last so thick and strong, that they resist all the attacks of the wind, and all the injuries of the air, during eight or nine months. About the beginning of October, or when the frost first commences, the whole community shut themselves up in the nest. During the winter they remain immoveable, and seemingly dead. But, when exposed to heat, they soon discover symptoms of life, and begin to creep. In this country, they seldom go out of the nest till the middle or end of April. When they shut themselves up for the winter, they are very small ; but, after they have fed for some days in spring upon the young and tender leaves, they find the nest itself, and all the entrances to it, too small for the increased size of their bodies. To remedy this inconve-

nieny, these disgusting reptiles know how to enlarge both the nest and its passages by additional operations accommodated to their present state. Into these new lodgings they retire when they want to repose, to screen themselves from the injuries of the weather, or to cast their skins. In fine, after casting their skins several times, the time of their dispersion arrives. From the beginning to near the end of June, they lead a solitary life. Their social disposition is no longer felt. Each of them spins a pod of coarse brownish silk. In a few days they are changed into chrysalids ; and, in eighteen or twenty days more, they are transformed into butterflies.

Caterpillars of another species, which Reaumur distinguishes by the appellation of the *processionary caterpillar*, live in society till their transformation into flies. These caterpillars are of the hairy kind, and are of a reddish colour. They inhabit the oak, and feed upon its leaves. When very young, they have no fixed or general habitation. But, after they have acquired about one half of their natural size, they assemble together, and construct a nest sufficient to accommodate the whole. The nests of these caterpillars are attached to the trunks of the oak, and are situated sometimes near the earth, and sometimes seven or eight feet above its surface. They consist of different strata, or layers, of silk, which are spun by the united labour of the whole community. Their figure is neither striking nor uniform. On the part of the oak to which they are fixed they form a protuberance similar to those knots which are seen upon trees. This protuberance sometimes resembles a segment of a circle, and sometimes it is three or four times longer than it is broad. Some of these nests are from eighteen to twenty inches long, and from five to six inches wide. About the middle of their convexity, they often rise more than four inches above the surface of the tree.

Between the trunk of the tree and the layers of silk a single hole is left, to allow the animals to go out in quest of food, and to retire into the nest after they are satiated. Notwithstanding the great bulk of these nests, and though there are often three or four of them upon the same tree, and never elevated above the height of distinct vision, they are not easily perceived; for the silk of which they are composed is cinereous, and resembles, in colour, those mosses with which the trunk of the oak is generally covered.

The inhabitants of a nest, which are numerous, march out, about the setting of the sun, to forage, under the conduct of a chief or leader, all whose movements they uniformly follow. The order they observe is singular. The first rank consists of single animals, the second of two, the third of three, the fourth of four, and sometimes more. In this manner they proceed in quest of food with all the regularity of disciplined troops. The chief or leader has no marks of pre-eminence; for any individual that happens first to issue from the nest, from that circumstance alone, becomes the leader of an expedition. After making a full repast upon the neighbouring leaves, they return to the nest in the same regular order; and this practice they continue during the whole period of their existence in the caterpillar state. It was from this strange regularity of movement that Reaumur, with much propriety, denominated these animals *processionary* caterpillars. When arrived at maturity, each individual spins a filken pod, is converted into a chrysalis, and afterwards assumes the form of a butterfly. This last transformation breaks all the bonds of their former association, and the female flies deposit their eggs, which, when hatched, produce new colonies, who exhibit the same oeconomy and manners.

There are several species of caterpillars who are real republicans, and whose discipline, manners, and genius, are

equally diversified as those of the inhabitants of different nations and climates. Some, like particular savages, construct a kind of hammocks, in which they take their victuals, repose, and spend their lives till the period of their transformation. Others, like the Arabs and Tartars, construct and live in silken tents, and, after consuming the neighbouring herbage, they leave their former habitations, and encamp on fresh pasture. Under these tents they are not only protected from the injuries of the weather, but they repose in them when sick, or in a state of inactivity. They go out of their tents at particular times in quest of food, and often to considerable distances ; but they never lose their way back. It is not by sight that they are directed with so much certainty to their abodes. Nature has furnished them with another guide for regaining their habitations. We pave our streets with stones ; but the caterpillars cover all their roads with silken threads. These threads make white tracks, which are often more than a sixth of an inch wide. It is by following these silken tracks, however complicated, that the caterpillars never miss their nests. If the road is broke by a man's finger drawn along it, or by any other accident, the caterpillars are greatly embarrassed. They stop suddenly at the interrupted space, and exhibit every mark of fear and of diffidence. Here the march stops, till an individual, more bold or more impatient than his companions, traverses the gap. In his passage, he leaves behind him a thread of silk, which serves as a bridge or conductor to the next that follows. By the progression of numbers, each of which spins a thread, the breach is soon repaired. We cannot suppose that these stupid animals cover their roads to prevent their wandering. But they never wander, because their roads are covered with silk. In this, as well as in many other instances, Nature obliges animals to embrace the most effectual means of self-preservation, and even of conve-

nency, without their perceiving the utility of their own operations. The caterpillars, whose manners we have been describing, spin almost continually, because they are continually obliged to evacuate a silky matter, secreted from their food by vessels destined for that purpose, and included in their intestines. In obeying this call of Nature, they effectually secure their retreat to their nest, and perhaps their existence. It may be said, that caterpillars associate for no other reason but because they are all produced at the same time from eggs deposited near each other. But many other species of caterpillars, who are brought to life in the very same circumstances, never associate or act in concert in the performance of any mutual labour. The silk-worms afford a similar example. It is true, they spontaneously remain assembled in the same place, which is of great advantage to manufacture. But the individuals of other species disperse immediately after birth, and never re-unite. Spiders, when newly hatched, begin with spinning a web in common; but they soon terminate this association by devouring one another.

As caterpillars do not engender till they arrive at the butterfly state, their associations have no respect to the rearing or education of young. Self-preservation and individual convenience are the only bonds of their union. A perfect equality reigns among them, without any distinction of sex, or even of size. Each takes his share of the common labour; and the whole society, which constitutes but one family, is the genuine issue of the same mother.

The association and oeconomy of the common ants merit some attention. With wonderful industry and activity they collect materials for the construction of their nest. They unite in numbers, and assist each other in excavating the earth, and in transporting to their habitation bits of straw, small pieces of wood, and other substances of a similar kind, which they employ in lining and supporting their subterra-

neous galleries. The form of their nest or hill is somewhat conical, and, of course, the water, when it rains, runs easily off, without penetrating their abode. Under this hill there are many galleries or passages which communicate with each other, and resemble the streets of a small city.

The ants not only associate for the purpose of constructing a common habitation, but for cherishing and protecting their offspring. Every person must have often observed, when part of a nest is suddenly exposed, their extreme solicitude for the preservation of their chrysalids or nymphs, which often exceed the size of the animals themselves. With amazing dexterity and quickness the ants transport their nymphs into the subterraneous galleries of the nest, and place them beyond the reach of any common danger. The courage and fortitude with which they defend their young is no less astonishing. The body of an ant was cut through the middle, and, after suffering this cruel treatment, so strong was its parental affection, with its head, and one half of the body, it carried off eight or ten nymphs. They go to great distances in search of provisions. Their roads, which are often winding and involved, all terminate in the nest.

The wisdom and foresight of the ants have been celebrated from the remotest antiquity. It has been asserted and believed, for near three thousand years, that they lay up magazines of provisions for the winter, and that they even cut off the germ of the grain to prevent it from shooting. But the ancients were never famed for accurate researches into the nature and operations of insects. These supposed magazines could be of no use to the ants ; for, like the marmots and dormice, they sleep during the winter. A very moderate degree of cold is sufficient to render them torpid. In fact, it is now well known that they amass no magazines of provisions. The grains which, with so much industry and la-

bour, they carry to their nest, are not intended to be food to the animals, but, like the bits of straw and wood, are employed as materials in the construction of their habitation.

2. *Improper Societies.* Many animals are gregarious, though they unite not with a view to any joint operation, such as constructing common habitations, or mutually and indiscriminately nourishing and protecting the offspring produced by the whole society. But, even among animals of this description, there are motives or bonds of association, and, in many instances, they mutually assist and defend each other from hostile assaults.

The ox is a gregarious animal. When a herd of oxen are pasturing in a meadow, if a wolf makes his appearance, they instantly form themselves in battle array, and present their united horns to the enemy. This warlike disposition often intimidates the wolf, and obliges him to retire.

In winter, the hinds and young stags associate, and form herds, which are always more numerous in proportion to the severity of the weather. One bond of their society seems to be the advantage of mutual warmth derived from each other's bodies. In spring they disperse, and the hinds conceal themselves in the forests, where they bring forth their young. The young stags, however, continue together; they love to browse in company; and necessity alone forces them to separate.

The Count de Buffon represents sheep as stupid creatures, which are incapable of defending themselves against the attacks of any rapacious animal. He maintains that the race must long ago have been extinguished, if man had not taken them under his immediate protection. But Nature has furnished every species of animated beings with weapons and arts of defence which are sufficient for individual preservation as well as the continuation of the kind. Sheep are endowed with a strong associating principle. When threat-

ened with an attack, like soldiers, they form a line of battle, and boldly face the enemy. In a natural state, the rams constitute one half of the flock. They join together and form the front. When prepared in this manner for repelling an assault, no lion or tiger can resist their united impetuosity and force.

A family of hogs, when in a state of natural liberty, never separate till the young have acquired strength sufficient to repel the wolf. When a wolf threatens an attack, the whole family unite their forces, and bravely defend each other.

The wild dogs of Africa hunt in packs, and carry on a perpetual war against other rapacious animals. The jackals of Asia and Africa likewise hunt in packs. But, though animals of this kind mutually assist each other in killing prey, individual advantage is the chief, if not the only bond of this temporary union.

Another kind of society is observable among domestic animals. Horses and oxen, when deprived of companions of their own species, associate, and discover a visible attachment. A dog and an ox, or a dog and a cow, when placed in certain circumstances, though the species are remote, and even hostile, acquire a strong affection for each other. The same kind of association takes place between dogs and cats, between cats and birds, &c. If domestic animals had a strong aversion to one another, man could not derive so many advantages from them. Horses, oxen, sheep, &c. by browsing promiscuously together, augment and meliorate the common pasture. By living under the same roof, and feeding in common, this associating principle is strengthened and modified by habit, which often commences immediately after birth. A single horse confined in an inclosure, discovers every mark of uneasiness. He becomes restless, neglects his food, and breaks through every fence in order to join his companions.

in a neighbouring field. Oxen and cows will not fatten in the finest pasture, if they are deprived of society.

From the facts and remarks contained in this chapter, it seems to be evident, that the principle of association in man, as well as in many other animals, is purely instinctive ; and that this principle may be strengthened and modified by the numberless advantages derived from it, by imitation, by habit, and by many other circumstances.

CHAPTER XVII.

Of the Docility of Animals.

OF all animals capable of culture, man is the most ductile. By instruction, imitation, and habit, his mind may be moulded into any form. It may be exalted by science and art to a degree of knowledge, of which the vulgar and uninformed have not the most distant conception. The reverse is melancholy. When the human mind is left to its own operations, and deprived of almost every opportunity of social information, it sinks so low, that it is nearly rivalled by the most sagacious brutes. The natural superiority of man over the other animals, as formerly remarked, is a necessary result of the great number of instincts with which his mind is endowed. These instincts are gradually unfolded, and produce, after a mature age, reason, abstraction, invention, science. To confirm this truth, it would be fruitless to have recourse to metaphysical arguments, which generally mislead and bewilder human reason. A diligent attention to the actual operations of Nature is sufficient to convince any mind that is not warped and deceived by popular prejudice, the fetters of authorities, as they are called, whether ancient or modern, or by the vanity of supporting preconceived opinions and favourite theories. Let any man reflect on the progress of children from birth to manhood. At first, their instincts are limited to obscure sensations, and to the performance of a few corporeal actions, to which they are prompted, or rather compelled, by certain stimulating impulses unnecessary to be mentioned. In a few months, their sensations are perceived to be more distinct, their bodily actions are better directed, new instincts are unfolded, and they assume a greater

appearance of rationality and of mental capacity. When still farther advanced, and after they have acquired some use of language, and some knowledge of natural objects, they begin to reason ; but their reasonings are feeble, and often preposterous. In this manner they uniformly proceed in improvement till they are actuated by the last instinct, at or near the age of puberty. After this period, they reason with some degree of perspicuity and justness. But, though their whole instincts are now unfolded and in action, every power of their minds requires, previous to its utmost exertions, to be agitated and polished by an examination of a thousand natural and artificial objects, by the experience and observations of those with whom they associate, by public or private instruction, by studying the writings of their predecessors and contemporaries, and by their own reflections, till they arrive at the age of thirty-five. Previous to that period, much learning may have been acquired, much genius may have been exerted ; but, before that time of life, judgment, abstraction, and the reasoning faculty, are not fully matured. This progress is the genuine operation of Nature, and the gradual source of human sagacity and mental powers. The same progress is to be observed in the powers of the body. It arrives, indeed, sooner at perfection than the mind. But, if the progress of the mind greatly preceded that of the body, what a miserable and awkward figure would human beings, at an early period of their existence, exhibit ? Active and vigorous minds, stimulated to command what the organs of their bodies were unable to obey, would produce peevishness, anger, regret, and every distressing passion.

The bodies of men, though not so ductile as their minds, are capable, when properly managed by early culture, of wonderful exertions. Men, accustomed to live in polished societies, have little or no idea of the activity, the courage, the patience, and the persevering industry of savages, when

simply occupied in hunting wild animals for food to themselves and their families. The hunger, the fatigue, the hardships, which they not only endure, but despise with fortitude, would amaze and terrify the imagination of any civilized European.

Beside man, many other animals are capable of being instructed. The ape-kind, and especially the larger species of them, imitate the actions of men without any instruction. This imitation they are enabled to perform with the greater exactness, on account of their structure. The orang-outang, a native of the southern regions of Africa and India, is as tall and as strong as a man. He has no tail. His face is flat. His arms, hands, toes, and nails, are perfectly similar to ours. He walks constantly on end ; and the features of his visage make a near approach to those of the human countenance. He has a beard on his chin, and no more hair on his body than men have when in a state of nature. He knows how to bear arms, to attack his enemies with stones, and to defend himself with a club. Of all the apes, the orang-outang, or *wild man*, as he is called by the Indians, has the greatest resemblance to a man both in the structure of his body and in his manners. There are two supposed species of orang-outang, a larger and a smaller. The latter has been several times brought to Europe, and accurate descriptions have been given both to his external and internal parts. But, with regard to the larger kind, who is said to exceed the ordinary stature of man, we have nothing to rely on but the relations of travellers. Bontius, who was the chief Physician in Batavia, affirms expressly, that he saw, with admiration, several individuals of this species walking on their two feet. Among others, he remarked a female, who seemed to have a sense of modesty, who covered her face with her hands when men approached her with whom she was unacquainted, who wept, groaned, and seemed to want nothing of humanity but

the faculty of speech*. Many other surprising actions performed by this animal are recorded by different voyagers, which it is unnecessary to repeat, especially as we have a sufficient number of facts attested by unequivocal evidence. The Count de Buffon, with much probability, considers what are called the large and small orang-outangs to be the same species of animals; for those hitherto brought to Europe were very young, and had not acquired one half of their stature.

'The orang-outang,' says Buffon, 'which I saw, walked always on two feet, even when carrying things of considerable weight. His air was melancholy, his movements measured, his dispositions gentle, and very different from those of other apes. He had neither the impatience of the Barbary ape, the maliciousness of the baboon, nor the extravagance of the monkeys. It may be alledged that he had the benefit of instruction; but the apes, which I shall compare with him, were educated in the same manner. Signs and words were alone sufficient to make our orang-outang act: But the baboon required a cudgel, and the other apes a whip; for none of them would obey without blows. I have seen this animal present his hand to conduct the people who came to visit him, and walk as gravely along with them as if he had formed a part of the company. I have seen him sit down at a table, unfold his towel, wipe his lips, use a spoon or a fork to carry the viands to his mouth, pour his liquor into a glass, and make it touch that of the person who drank along with him. When invited to drink tea, he brought a cup and a saucer, placed them on the table, put in sugar, poured out the tea, and allowed it to cool before he drank it. All these actions he performed without any other instigation than the signs or verbal orders of his master, and often of his own accord. He did no

* Juc. Pont. Hist. Nat. Ind., cap. 32.

injury to any person : He even approached company with circumspection, and presented himself as if he wanted to be caressed. He was very fond of dainties, which every body gave him : And, as his breast was diseased, and he was afflicted with a teasing cough, this quantity of sweetmeats undoubtedly contributed to shorten his life. He lived one summer in Paris, and died in London the following winter. He eat almost every thing ; but preferred ripe and dried fruits to all other kinds of food. He drank a little wine ; but spontaneously left it for milk, tea, or other mild liquors*.

M. de la Brosse purchased two orang-outangs from a Negro, whose age exceeded not twelve months. ‘ These animals,’ he remarks, ‘ have the instinct of sitting at table like men. They eat every kind of food without distinction. They use a knife, a fork, or a spoon, to cut or lay hold of what is put upon their plate. They drink wine and other liquors. We carried them abroad. At table, when they wanted any thing, they made themselves understood by the cabin-boy : And, when the boy refused to give them what they demanded, they sometimes became enraged, seized him by the arm, bit, and threw him down. The male was seized with sickness on the road. He made himself be attended as a human being. He was even twice bled in the right arm : And, whenever he found himself afterwards in the same condition, he held out his arm to be bled, as if he knew that he had formerly received benefit from that operation.’

We are informed by Francis Pyrard, ‘ that, in the province of Sierra-Leona, there is a species of animals called *baris*, (the orang-outang,) who are strong and well limbed, and so industrious, that, when properly trained and fed, they work like servants ; that they generally walk on the

* Buffon, vol. 8. page 86. transf.

' two hind-feet ; that they pound any substances in a mortar ; that they go to bring water from the river in small pitchers, which they carry full on their heads. But, when they arrive at the door, if the pitchers are not soon taken off, they allow them to fall ; and, when they perceive the pitcher overturned and broken, they weep and lament*.' With regard to the education of these animals, the testimony of Schoutton corresponds with that of Pyrard. 'They are taken,' says he, 'with snares, taught to walk on their hind-feet, and to use their fore-feet as hands in performing different operations, as rinsing glasses, carrying drink round the company, turning a spit,' &c. † Guat informs us, that he saw at Java a very extraordinary ape. It was a female. She was very tall, and often walked erect on her hind-feet. On these occasions, she concealed with her hands the parts which distinguish the sex. She made her bed very neatly every day, lay upon her side, and covered herself with the bed-clothes. When her head ached, she bound it up with her handkerchief ; and it was amusing to see her thus hooded in bed. I could relate many other little articles which appeared to be extremely singular. But I admired them not so much as the multitude ; because, as I knew the design of bringing her to Europe to be exhibited as a shew, I was inclined to think that she had been taught many of these monkey tricks, which the people considered as being natural to the animal. She died in our ship, about the latitude of the Cape of Good Hope. The figure of this ape had a very great resemblance to that of man‡.'

We have now enumerated the principal facts regarding this extraordinary animal, which have been related by voyagers of credit, and by those who have seen and examined him in

* Voyages de Francois Pyrard, tom. 2. page 331.

† Voyages de Schoutton aux Indes Orientales.

‡ Voyages de Fran, le Guat, tom. 2. page 96.

Europe; and shall only remark, that, notwithstanding the great similarity of his structure and organs to those of the human species, his genius and talents seem to be very limited. The form of his body enables him to imitate every human action. But, though he has the organs of speech, he is destitute of articulate language. If, however, he were domesticated, and proper pains bestowed for instructing him, he might unquestionably be taught to articulate. But, supposing this point to be obtained, if he remained incapable of reflection, if he was unable to comprehend the meaning of words, or to discover by his expressions a degree of intellect greatly superior to that of the brute creation, which I imagine would be the case, he could never, as some authors have held forth, be exalted to the distinguished rank of human beings.

Of all quadrupeds, of whose history and manners we have any proper knowledge, the elephant is the most remarkable both for docility and understanding. Though his size is enormous, and his members rude and disproportioned, which give him, at first sight, the aspect of dullness and stupidity, his genius is great, and his sagacious manners, and his sedate and collected deportment, are almost incredible. He is the largest and strongest of all terrestrial animals. Though naturally brave, his dispositions are mild and peaceable. He is an associating animal, and seldom appears alone in the forests. When in danger, or when they undertake a predatory expedition into cultivated fields, the elephants assemble in troops. The oldest takes the lead; the next in seniority brings up the rear; and the young and the feeble occupy the center. In the forests and solitudes they move with less precaution; but never separate so far asunder as to render them incapable of affording each other mutual assistance when danger approaches. A troop of elephants constitutes a most formidable band. Wherever they march, the forest seems to fall before them. They bear down the branches

upon which they feed ; and, if they enter into an inclosure, they soon destroy all the labours of the husbandman. Their invasions are the more tremendous, as there is hardly any means of repelling them ; for, to attack a troop, when thus united, would require a little army. It is only when one or two elephants happen to linger behind the rest, that the hunters dare exert their art and ingenuity in making an attack ; for any attempt to disturb the troop would certainly prove fatal to the assailants. When an insult is offered, the elephants instantly move forward against the offender, toss him in the air with their tusks, and afterwards trample him to pieces under their feet, or rather pillars of flesh and bone. Let not the character of this noble and majestic animal, however, be misrepresented. With force and dignity he resents every affront ; but, when not disturbed by petulence or actual injury, he never shows an hostile intention either against man or any other animal. Elephants live entirely on vegetables, and have no thirst for blood. Such is their social and generous disposition, that, when an individual chances to meet with a luxurious spot of pasture, he immediately calls to his companions, and invites them to partake of his good fortune.

The elephant possesses all the senses in perfection : But, in the sense of touching, he excels all the brute creation. His trunk is the chief instrument of this sense. In an elephant of fourteen feet high, the trunk is about eight feet long, and five feet and an half in circumference at the base. It is a large fleshy tube, divided through its whole extent by a septum or partition. It is capable of motion in every direction. The animal can shorten or lengthen it at pleasure. It answers every purpose of a hand ; for it grasps large objects with great force, and its extremity can lay hold of a sixpence, or even of a pin. The trunk of the elephant affords him the same means of address as the ape. It serves the purposes of an arm and a hand. By this instrument, the ele-

phant conveys large or small bodies to his mouth, places them on his back, embraces them fast, or throws them forcibly to a distance. In a state of nature and perfect freedom, the dispositions of the elephant are neither sanguinary nor ferocious. They are gentle creatures, and never exert their strength, or employ their weapons, but in defending themselves or protecting their companions. Even when deprived of the instruction of men, they possess the sagacity of the beaver, the address of the ape, and the acuteness of the dog. To these mental talents are added the advantages of amazing bodily strength, and the experience and knowledge he acquires by living at least two centuries. With his trunk he tears up trees. By a push of his body he makes a breach in a wall. To this prodigious strength he adds courage, prudence, and coolness of deportment. As he never makes an attack but when he receives an injury, he is universally beloved; and all animals respect, because none have any reason to fear him. In all ages, men have entertained a veneration for this most magnificent and sagacious of terrestrial creatures. The ancients regarded him as a miracle of Nature, and he is, in reality, one of her greatest efforts. But they have greatly exaggerated his faculties. Without hesitation, they have ascribed to him high intellectual powers and moral virtues. Pliny, Aelian, Plutarch, and other authors of a more modern date, have bestowed on the elephant not only rational manners, but an innate religion, a kind of daily adoration of the sun and moon, the use of ablution before worship, a spirit of divination, piety toward heaven and their fellow creatures, whom they assist at the approach of death, and, after their decease, bedew them with tears, and cover their bodies with earth.

When tamed and instructed by man, the elephant is soon rendered the mildest and most obedient of all domestic animals. He loves his keeper, caresses him, and anticipates

his commands. He learns to comprehend signs, and even to understand the expression of sounds. He distinguishes the tones of command, of anger, and of approbation, and regulates his actions by his perceptions. The voice of his master he never mistakes. His orders are executed with alacrity, but without any degree of precipitation. His movements are always measured and sedate, and his character seems to correspond with the gravity of his mass. To accommodate those who mount him, he readily learns to bend his knees. With his truuk he salutes his friends, uses it for raising burdens, and assists in loading himself. He loves to be clothed, and seems to be proud of gaudy trappings. In the southern regions, he is employed in drawing waggons, ploughs, and chariots. ‘I was eye-witness,’ says P. Philippe, ‘to the following facts. At Goa, there are always some elephants employed in the building of ships. I one day went to the side of the river, near which a large ship was building in the city of Goa, where there is a large area filled with beams for that purpose. Some men tie the ends of the heaviest beams with a rope, which is handed to the elephant, who carries it to his mouth, and, after twisting it round his trunk, draws it, without any conductor, to the place where the ship is building, though it had only once been pointed out to him. He sometimes drew beams so large that more than twenty men would have been unable to move. But, what surprised me still more, when other beams obstructed the road, he elevated the ends of his own beams, that they might run easily over those which lay in his way. Could the most enlightened man do more *?’ When at work, the elephant draws equally, and, if properly managed, never turns restive. The man who conducts the animal generally rides on his neck, and employs a hooked iron rod, or bodkin, with which he pricks the head or sides of the ears, in order to push the

* Voyage d'Orient. page 367.

creature forward, or to make him turn. But words are commonly sufficient. The attachment and affection of the elephant are sometimes so strong and durable that he has been known to die of grief, when, in an unguarded paroxysm of rage, he had killed his guide.

Before the invention of gun-powder, elephants were employed in war by the African and Asiatic nations. ‘From time immemorial,’ says Schouten, ‘the Kings of Ceylon, of Pegu, and of Aracan, have used elephants in war. Naked sabres were tied to their trunks, and on their backs were fixed small wooden castles, which contained five or six men armed with javelins, and other weapons *.’ The Greeks and Romans, however, soon became acquainted with the nature of these monstrous warriors. They opened their ranks to let the animals pass, and directed all their weapons, not against the elephants, but their conductors. Since fire has now become the element of war, and the chief instrument of destruction, elephants, who are terrified both at the flame and the noise, would be more dangerous than useful in our modern battles. The Indian Kings, however, still arm elephants in their wars. In Cochin, and other parts of Malabar, all the warriors who fight not on foot are mounted on elephants †. The same practice obtains in Tonquin, Siam, and Pegu. In these countries, the kings and nobles at public festivals are always preceded and followed by numerous trains of elephants, pompously adorned with pieces of shining metal, and clothed with rich garments. Their tusks are ornamented with rings of gold and silver; their ears and cheeks are painted with various colours; they are crowned with garlands; and a number of small bells are fixed to different parts of their bodies. They delight in gaudy attire; for they are cheerful and carefree in proportion to the num-

* Voyage de Schouten, page 32.

† Thevenot, tom. 3. page 261.

ber and splendour of their ornaments. The Asiatics, who were very anciently civilized, perceiving the sagacity and docility of the elephant, educated him in a systematic manner, and modified his dispositions according to their own manners, and the useful labours in which his strength and dexterity could be employed.

A domestic elephant performs more labour than could be accomplished by six horses ; but he requires much care and a great deal of food. He is subject to be over-heated, and must be led to the water twice or thrice a-day. He easily learns to bathe himself. With his trunk he sucks up large quantities of water, carries it to his mouth, drinks part of it, and, by elevating his trunk, makes the remainder run over every part of his body. To give some idea of the labour he performs, and the docility of his dispositions, it is worthy of remark, that, in India, all the bales, sacks, and tuns transported from one place to another, are carried by elephants. They carry burdens on their bodies, their necks, their tusks, and even in their mouths, by giving them the end of a rope, which they hold fast with their teeth. Uniting sagacity with strength, they never break or injure any thing committed to their charge. From the margins of the rivers, they put weighty bundles into boats without wetting them, lay them down gently, and arrange them where they ought to be placed. When the goods are disposed as their masters direct, they examine with their trunks whether the articles are properly stowed ; and, if a cask or tun rolls, they go spontaneously in quest of stones to prop and render it firm.

In the elephant, the sense of smelling is acute, and he is passionately fond of odoriferous flowers, which he collects one by one, forms them into a nosegay, and, after gratifying his nose, conveys them to his mouth.

In India, the domestic elephants, to whom the use of water is as necessary as that of air, are allowed every possible convenience for bathing themselves. The animal goes into a river till the water reaches his belly. He then lies down on one side, fills his trunk several times, and dexterously throws the water on such parts as happen to be uncovered. The master, after cleaning and currying one side, desires the animal to turn to the other, which command he obeys with the greatest alacrity ; and, when both sides have been properly cleaned, he comes out of the river, and stands some time on the bank to dry himself. The elephant, though his mass be enormous, is an excellent swimmer ; and, of course, he is of great use in the passage of rivers. When employed on occasions of this kind, he is often loaded with two pieces of cannon which admit three or four pound balls, beside great quantities of baggage and several men fixed to his ears and his tail. When thus heavily loaded, he spontaneously enters the river and swims over with his trunk elevated in the air for the benefit of respiration. He is fond of wine and ardent spirits. By showing him a vessel filled with any of these liquors, and promising him it as a reward of his labours, he is induced to exert the greatest efforts, and to perform the most painful tasks. The elephant, as we are informed by M. de Bussey, quoted by the Count de Buffon, is employed in dragging artillery over mountains, and, on these occasions, his sagacity and docility are conspicuous. Horses or oxen, when yoked to a cannon, make all their exertions to pull it up a declivity. But the elephant pushes the breach forward with his front, and, at each effort, supports the carriage with his knee, which he places against the wheel. He seems to understand what his *cornack*, or conductor, says to him. When his conductor wants him to perform any painful labour, he explains the nature of the operation, and gives the reasons which should induce him to obey. If the

elephant shows a reluctance to the task, the cornack promises to give him wine, arrack, or any other article that he is fond of, and then the animal exerts his utmost efforts. But to break any promise made to him is extremely dangerous. Many cornacks have fallen victims to indiscretions of this kind. ‘At Dehan,’ says M. de Bussey, ‘an elephant, from revenge, killed his cornack. The man’s wife, who beheld the dreadful scene, took her two children, and threw them at the feet of the enraged animal, saying, *Since you have slain my husband, take my life also, as well as that of my children.*’ The elephant instantly stopped, relented, and, as if stung with remorse, took the oldest boy in its trunk, placed him on its neck, adopted him for his cornack, and would never allow any other person to mount it.’

From the members of the Royal Academy of Sciences, we learn some curious facts with regard to the manners of the Versailles elephant. This elephant, they remark, seemed to know when it was mocked, and remembered the affront till it had an opportunity of revenge. A man deceived it, by pretending to throw some food into its mouth. The animal gave him such a blow with its trunk as knocked him down, and broke two of his ribs. A painter wanted to draw the animal in an unusual attitude, with its trunk elevated, and its mouth open. The painter’s servant, to make it remain in this position, threw fruits into its mouth, but generally made only a faint of throwing them. This conduct enraged the elephant ; and, as if it knew that the painter was the cause of this teasing impertinence, instead of attacking the servant, it eyed the master, and squirted at him from its trunk such a quantity of water as spoiled the paper on which he was drawing. This elephant commonly made less use of its strength than its address. It loosed, with great ease and coolness, the buckle of a large double leathern strap, with which its leg was fixed ; and, as the servants had

wrapped the buckle round with a small cord, and tied many knots upon it, the creature, with much deliberation, loosed the whole, without breaking either the strap or the cord.

It is remarked by le P. Vincent Marie, that the elephant, when in a domestic state, is highly esteemed for his gentleness, docility, and friendship to his governour. When destined to the immediate service of princes, he is sensible of his good fortune, and maintains a gravity of demeanour corresponding to the dignity of his situation. But, if, on the contrary, less honourable labours are affigned to him, he grows melancholy, frets, and evidently discovers that he is humbled and depressed. He is fond of children, caresses them, and appears to discern the innocence of their manners. The Dutch voyagers relate*, that by giving elephants what is agreeable to them, they are soon rendered perfectly tame and submissive. They are so sagacious, that they may be said to be destitute of the use of language only. They are proud and ambitious ; and they are so grateful for good usage, that, as a mark of respect, they bow their heads in passing houses where they have been hospitably received. They allow themselves to be led and commanded by a child ; but they love to be praised and caressed. When a wild elephant is taken, the hunters tie his feet, and one of them accosts and salutes him, makes apologies for binding him, protests that no injury is intended, tells him, that, in his former condition, he frequently wanted food, but that, henceforward, he shall be well treated, and that every promise shall be performed to him. This soothing harangue is no sooner finished than the elephant placidly follows the hunter†. From this fact, however, we must not conclude that the elephant understands language, but that, like the dog, he has a strong discerning faculty. He distinguishes esteem from con-

* *Voyage de la Compagnie des Indes de Hollande*, tom. I. page 413.

† *Voyage d'Orient*, du P. Phillippe, page 366.

tempt, friendship from hatred, and many other emotions which are expressed by human gestures and features. For this reason, the elephant is more easily tamed by mildness than by blows.

'I have frequently remarked,' says Edward Terry*, 'that the elephant performs many actions which seem to proceed more from reason than from instinct. He does every thing that his master commands. If he wants to terrify any person, he runs upon him with every appearance of fury, and, when he comes near, stops short, without doing the person the smallest injury. When the master chooses to affront any man, he tells the elephant, who immediately collects water and mud with his trunk, and squirts it upon the object pointed out to him. The Mogul keeps some elephants who serve as executioners to criminals condemned to death. When the conductor orders one of these animals to dispatch the poor criminals quickly, he tears them to pieces in a moment with his feet: But, if desired to torment them slowly, he breaks their bones one after another, and makes them suffer a punishment as cruel as that of the wheel.'

Next to the elephant, the dog seems to be the most docile quadruped. A wild dog is a passionate, ferocious, and sanguinary animal. But, after he is reduced to a domestic state, these hostile dispositions are suppressed, and they are succeeded by a warm attachment, and a perpetual desire of pleasing. The perceptions and natural talents of the dog are acute. When these are aided by instruction, the sagacity he discovers, and the actions he is taught to perform, often excite our wonder. Those animals which man has taken under his immediate protection are taught to perform artificial actions, or have their natural instincts improved, by three modes of instruction, punishment, reward, and imitation. More ductile in his nature than most other animals, the dog

* *Terry's Voyage to the East Indies*, page 15.

not only receives instruction with rapidity, but accommodates his behaviour and deportment to the manners and habits of those who command him. He assumes the very tone of the family in which he resides. Eager, at all times, to please his master, or his friends, he furiously repels beggars; because he probably, from their dress, conceives them to be either thieves, or competitors for food.

Though every dog, as well as every man, is naturally a hunter, the dexterity of both is highly improved by experience and instruction. The varieties of dogs, by frequent intermixtures with those of different climates, and perhaps with foxes and wolves, are so great, and their instincts are so much diversified, that, even though they produce with each other, we should be apt to regard them as different species. What a difference between the natural dispositions of the shepherd's dog, the spaniel, and the grey-hound? The shepherd's dog, independently of all instruction, seems to be endowed by Nature with an innate attachment to the preservation of sheep and cattle. His docility is likewise so great, that he not only learns to understand the language and commands of the shepherd, and obeys them with faithfulness and alacrity, but, when at distances beyond the reach of his master's voice, he often stops, looks back, and recognises the approbation or disapprobation of the shepherd by the mere waving of his hand. He reigns at the head of a flock, and is better heard than the voice of his master. His vigilance and activity produce order, discipline, and safety. Sheep and cattle are peculiarly subjected to his management, whom he prudently conducts and protects, and never employs force against them, except for the preservation of peace and good order. But, when the flock committed to his charge is attacked by the fox, or wolf, or other rapacious animals, he makes a full display of his courage and sagacity. In situations of this kind, both his natural and acquired talents are

exerted. Three shepherds dogs are said to be a match for a bear, and four for a lion.

Every person knows the docility and sagacity of such dogs as are employed in conducting blind mendicants. Johannes Faber, as quoted by Mr. Ray, informs us, that he knew a blind beggar who was led through the streets of Rome by a middle sized dog. This dog, beside leading his master in such a manner as to protect him from all danger, learned to distinguish not only the streets, but the houses where his master was accustomed to receive alms twice or thrice a-week. Whenever the animal came to any of these streets, with which he was well acquainted, he would not leave it till a call had been made at every house where his master was usually successful in his petitions. When the beggar began to ask alms, the dog, being wearied, lay down to rest ; but the master was no sooner served or refused, than the dog rose spontaneously, and, without either order or sign, proceeded to the other houses where the beggar generally received some gratuity. I observed, says he, not without pleasure and surprise, that, when a halfpenny was thrown from a window, such was the sagacity and attention of this dog, that he went about in quest of it, lifted it from the ground with his mouth, and put it into his master's hat. Even when bread was thrown down, the animal would not taste it, unless he received a portion of it from the hand of his master. Without any other instruction than imitation, a mastiff, when accidentally shut out from a house which his master frequented, uniformly rung the bell for admittance. Dogs can be taught to go to market with money, to repair to a known butcher, and to carry home the meat in safety. They can be taught to dance to music, and to search for and find any thing that is lost*.

* For these, and many other instances of the sagacity and docility of the dog, the reader may consult Synopsis Quadrupedum a Joanne Raio, p. 6. &c.

There is a dog at present belonging to a grocer in Edinburgh, who has for some time amused and astonished the people in the neighbourhood. A man who goes through the streets ringing a bell and selling penny pies, happened one day to treat this dog with a pye. The next time he heard the pyeman's bell, he ran to him with impetuosity, seized him by the coat, and would not suffer him to pass. The pyeman, who understood what the animal wanted, showed him a penny, and pointed to his master, who stood in the street-door, and saw what was going on. The dog immediately supplicated his master by many humble gestures and looks. The master put a penny into the dog's mouth, which he instantly delivered to the pyeman, and received his pye. This traffick between the pyeman and the grocer's dog has been daily practised for months past, and still continues.

Dogs, horses, and even hogs, by rewards and punishments, and, I am afraid, often by cruelty, may be taught to perform actions, as we have frequently seen in public exhibitions, which are truly astonishing. But of these we must not enter into any detail.

With regard to the horse, the gentleness of his dispositions, and the docility of his temper, are so well and so universally known, that it is unnecessary to dwell long upon the subject. To give some idea of what instruction horses receive when in a domestic state, we shall mention some traits of their form and manners when under no restraints. In South America the horses have multiplied prodigiously, and, in that thinly inhabited country, live in perfect freedom. They fly from the presence of man. They wander about in troops, and devour, in immense meadows, the productions of a perpetual spring. Wild horses are stronger, lighter, and more nervous, than the generality of those which are kept in a domestic state. They are by no means ferocious. Though superior in strength to most animals, they never

make an attack. When assaulted, however, they either disdain the enemy, or strike him dead with their heels. They associate in troops from mutual attachment, and neither make war with other animals nor among themselves. As their appetites are moderate, and they have a few objects to excite envy or discord, they live in perpetual peace. Their manners are gentle, and their tempers social. Their force and ardour are rendered conspicuous only by marks of emulation. They are anxious to be foremost in the course, to brave danger in crossing a river, or in leaping a ditch or precipice ; and, it is said, that those horses which are most adventurous and expert in these natural exercises, are, when domesticated, the most generous, mild, and tractable.

Wild horses are taken notice of by several of the ancients. Herodotus mentions white wild horses on the banks of the Hypanis in Scythia. He likewise tells us, that, in the northern part of Thrace, beyond the Danube, there were wild horses covered all over with hair five inches in length. The wild horses in America are the offspring of domestic horses originally transported thither from Europe by the Spaniards. The author of the history of the Buccaneers* informs us, that troops of horses, sometimes consisting of 500, are frequently met with in the island of St. Domingo ; that, when they see a man, they all stop ; and that one of their number approaches to a certain distance, blows through his nostrils, takes flight, and is instantly followed by the whole troop. He describes them as having gross heads and limbs, and long necks and ears. The inhabitants tame them with ease, and then train them to labour. In order to take them, gins of ropes are laid in the places where they are known to frequent. When caught by the neck, they soon strangle themselves, unless some person arrive in time to disentangle them. They are tied to trees by the body and limbs, and are left in that

* L'Hist. des Avanteur, Flibustiers, tom. I. page 110.

situation two days without victuals or drink. This treatment is generally sufficient to render them more tractable, and they soon become as gentle as if they had never been wild. Even when any of these horses, by accident, regain their liberty, they never resume their savage state, but know their masters, and allow themselves to be approached and retaken.

From these, and similar facts, it may be concluded, that the dispositions of horses are gentle, and that they are naturally disposed to associate with man. After they are tamed they never forsake the abodes of men. On the contrary, they are anxious to return to the stable. The sweets of habit seem to supply all they have lost by slavery. When fatigued, the mansion of repose is full of comfort. They smell it at considerable distances, can distinguish it in the midst of populous cities, and seem uniformly to prefer bondage to liberty. By some attention and address colts are first rendered tractable. When that point is gained, by different modes of management, the docility of the animal is improved, and they soon learn to perform with alacrity the various labours assigned to them. The domestication of the horse is perhaps the noblest acquisition from the animal world which has ever been made by the genius, the art, and the industry of man. He is taught to partake of the dangers and fatigues of war, and seems to enjoy the glory of victory. He encounters death with ardour and with magnanimity. He delights in the tumult of arms, and attacks the enemy with resolution and alacrity. It is not in perils and conflicts alone that the horse co-operates with the dispositions of his master. He even seems to participate of human pleasures and amusements. He delights in the chase and the tournament, and his eyes sparkle with emulation in the course. Though bold and intrepid, however, he does not allow himself to be hurried on by a furious ardour. On proper occasions, he re-

prefers his movements, and knows how to check the natural fire of his temper. He not only yields to the hand, but seems to consult the inclination of his rider. Always obedient to the impressions he receives, he flies or stops, and regulates his motions solely by the will of his master.

Mr. Ray, who wrote about the end of last century, informs us, that he had seen a horse who danced to music, who, at the command of his master, affected to be lame, who simulated death, lay motionless with his limbs extended, and allowed himself to be dragged about, till some words were pronounced, when he instantly sprung upon his feet*. Facts of this kind would scarcely receive credit, if every person were not now acquainted with the wonderful docility of the horses educated by Astley, and other public exhibitors of horsemanship. In exhibitions of this kind, the docility and prompt obedience of the animals deserve more admiration than the dexterous feats of the men.

Animals of the ox-kind, in a domestic state, are dull and phlegmatic. Their sensibility and talents seem to be very limited. But we should not pronounce rashly concerning the genius and powers of animals in a country where their education is totally neglected. In all the southern provinces of Africa and Asia, there are many wild bisons, or bunched oxen, which are taken when young and tamed. They are soon taught to submit, without resistance, to all kinds of domestic labour. They become so tractable, that they are managed with as much ease as our horses. The voice of their master is alone sufficient to make them obey, and to direct their course. They are shod, curried, caressed, and supplied abundantly with the best food. When managed in this manner, these animals appear to be different creatures from our oxen. The oxen of the Hottentots are favourite domestics, companions in amusements, assistants in all labori-

* Raii Synopsis Animalium Quadrupedum, page 10,

ous exercises, and participate the habitation, the bed, and the table of their masters. As their nature is improved by the gentleness of their education, by the kind treatment they receive, and the perpetual attention bestowed on them, they acquire sensibility and intelligence, and perform actions which one would not expect from them. The Hottentots train their oxen to war. In all their armies there are considerable troops of these oxen, which are easily governed, and are let loose by the chief when a proper opportunity occurs. They instantly dart with impetuosity upon the enemy. They strike with their horns, kick, overturn, and trample under their feet every thing that opposes their fury. They run ferociously into the ranks, which they soon put into the utmost disorder, and thus pave the way for an easy victory to their masters*. These oxen are likewise instructed to guard the flocks, which they conduct with dexterity, and defend them from the attacks of strangers, and of rapacious animals. They are taught to distinguish friends from enemies, to understand signals, and to obey the commands of their master. When pasturing, at the smallest signal from the keeper, they bring back and collect the wandering animals. They attack all strangers with fury, which renders them a great security against robbers. These *brackeleys*, as they are called, know every inhabitant of the kraal, and discover the same marks of respect for all the men, women, and children, as a dog does for those who live in his master's house. These people may, therefore, approach their cattle with the greatest safety. But, if a stranger, and particularly an European, should use the same freedom, without being accompanied with one of the Hottentots, his life would be in imminent danger†.

* Voyage de Cap, par Kolbe, tom. I. page 160.

† Voyage de Cap, par Kolbe, page 307.

Notwithstanding the many surprising actions which different quadrupeds may be taught to perform, none of them, though their organs are much more perfect than those of birds, have ever been able to pronounce articulate sounds. But many birds, without much instruction, learn to pronounce words, and even sentences. In parrots, the distinguishing accuracy of their ear, the acuteness of their attention, and their strong instinctive propensity to imitate sounds of every kind, have justly procured them universal admiration. When in a state of domestication, the parrot learns to pronounce the common street-calls, beside many words and phrases occasionally employed by the family in which he resides. Though the limitation of his mental powers does not permit him to learn any extent of language, or the proper use and meaning of words, he not unfrequently discovers the association between the object and the sound. A woman every morning passed the window, where a parrot's cage was fixed, calling salt. The parrot soon learned to imitate the call. But, before any sound could be heard, he no sooner cast his eye upon the woman than he uttered her usual call. In this, and many other similar cases, the objects and the sounds are evidently connected in the mind of the animal. How far these associations might be carried by a patient and persevering education, it is difficult to determine. In this manner, however, parrots might be taught a considerable vocabulary of substantive nouns, or the proper names of common objects. But his intellect, it is more than probable, would never reach the use of the verb, and other parts of speech.

Beside parrots, jays, &c. who learn to pronounce articulate sounds, there is another race of birds whose docility deserves to be mentioned. Singing birds, those lively and spirited little animals, attempt not to articulate. But their musical ears are as delicate and discerning as their voices are

melodious and delightful. The vivacity, the extent of voice, and the imitative powers of these beautiful creatures, have at all times excited the attention and conciliated the affections of mankind. When domesticated, these birds, beside their natural notes, soon acquire the faculty of singing considerable parts of artificial tunes. These imitations are effects of natural instinct. But, in exhibitions, I have seen linnets simulate death, and remain perfectly tranquil and unmoved, when small cannons were fired, within an inch of their bodies, from a wooden fort. These little creatures have even been taught to lay hold of a match and fire the cannons themselves.

The docility and sagacity of animals have always been considered as wonderful. But this wonder is partly the effect of inattention ; for, though man is unquestionably the chief of the animal creation, the other animals, according to the number of instincts, or, which amounts to the same thing, according to the mental powers with which Nature has endowed them, comparatively approach to or recede from the sagacity and genius of the human species. The whole is a graduated scale of intelligence. A philosopher should, therefore, contemplate and admire the whole, but should never be surprised at any partial exhibitions of the general scene of intellect and animation.

We shall conclude this subject with a few remarks concerning the changes produced in animals by DOMESTICATION.

Climate and food are the chief causes which produce changes in the magnitude, figure, colour, and constitution, of wild animals. But, beside these causes, there are others which have an influence upon animals when reduced to a domestic or unnatural state. When at perfect liberty, animals seem to have selected those particular zones or regions of the globe which are most consonant to the nature and constitution of each particular tribe. There they spontaneously remain, and

never, like man, disperse themselves over the whole surface of the earth. But, when obliged by man, or by any great revolution of Nature, to abandon their native soil, they undergo changes so great, that, to recognise and distinguish them, recourse must be had to the most accurate examination. If we add to climate and food, those natural causes of alteration in free animals, the empire of man over such of them as he has reduced to servitude, the degree to which tyranny degrades and disfigures Nature will appear to be greatly augmented. The mouflon, the stock from which our domestic sheep have derived their origin, is comparatively a large animal. He is as fleet as a stag, armed with horns and strong hoofs, and covered with coarse hair. With these natural advantages, he dreads neither the inclemency of the sky, nor the voracity of the wolf. By the swiftness of his course, he not only escapes from his enemies, but he is enabled to resist them by the strength of his body and the solidity of his arms. How different is this animal from our domestic sheep, who are timid, weak, and unable to defend themselves? Without the protection of man, the whole race would soon be extirpated by rapacious animals and by winter-storms. In the warmest climates of Africa and of Asia, the mouflon, who is the common parent of the sheep, appears to be less degenerated than in any other region. Though reduced to a domestic state, he has preserved his stature and his hair; but the size of his horns is diminished. The sheep of Barbary, Egypt, Arabia, Persia, &c. have undergone greater changes; and, in proportion as they approach toward either pole, they diminish in size, in strength, in swiftness, and in courage. In relation to man, they are improved in some articles, and vitiated in others. Their coarse hair is converted into fine wool. But, with regard to Nature, improvement and degeneration amount to the same thing; for both imply an alteration of the original constitution.

The ox is more influenced by nourishment than any other domestic animal. In countries where the pasture is luxuriant, the oxen acquire a prodigious size. To the oxen of Æthiopia and some provinces of Asia, the ancients gave the appellation of *Bull-elephants*, because, in these regions, they approach to the magnitude of the elephant. This effect is chiefly produced by the abundance of rich and succulent herbage. The Highlands of Scotland, and indeed every high and northern country, afford striking examples of the influence of food upon the magnitude of cattle. The oxen, as well as the horses, in the more northern parts of Scotland, are extremely diminutive ; but, when transported to richer pasture, their size is augmented, and the qualities of their flesh are improved. The climate has likewise a considerable influence on the nature of the ox. In the northern regions of both continents, he is covered with long soft hair. He has likewise a large bunch on his shoulders ; and this deformity is common to the oxen of Asia, Africa, and America. Those of Europe have no bunch. The European oxen, however, seem to be the primitive race, to which the bunched kind ascend, by intermixture, in the second or third generation. The difference in their size is remarkably great. The small zebu, or bunched ox of Arabia, is not one tenth part of the magnitude of the Æthiopian bull-elephant.

The influence of food upon the dog-kind seems not to be great. In all his variations and degradations, he appears to follow the differences of climate. In the warmest climates, he is naked ; in the northern regions, he is covered with a coarse thick hair ; and he is adorned with a fine silky robe in Spain and Syria, where the mild temperature of the air converts the hair of most quadrupeds into a kind of silk. Beside these external variations produced by climate, the dog undergoes other changes, which proceed from his situation, his captivity, and the nature of the intercourse he holds with

man. His size is augmented or diminished by obliging the smaller kinds to unite together, and by observing the same conduct with the larger individuals. The shortening of the tail and ears proceeds also from the hand of man. Dogs who have had their ears and tails cut for a few generations, transmit these defects, in a certain degree, to their descendants. Pendulous ears, the most certain mark of domestic servitude and of fear, are almost universal. Of many races of dogs, a few only have retained the primitive state of their ears. Erect ears are now confined to the wolf-dog, the shepherd's dog, and the dog of the North.

The colour of animals is greatly variegated by domestication. The dog, the ox, the sheep, the goat, the horse, have assumed all kinds of colours and even mixtures of colours, in the same individuals. The hog has changed from black to white; and white, without the intermixture of spots, is generally accompanied with essential imperfections. Men who are remarkably fair, and whose hair is white, have generally a defect in their hearing, and, at the same time, weak and red eyes. Quadrupeds which are entirely white have likewise red eyes and a dullness of hearing. The variations from the original colour are most remarkable in our domestic fowls. In a brood of chickens, though the eggs be laid by the same hen, and though the female be impregnated by the same male, not one of them has the same colours with another.

Domestication not only changes the external appearances of animals, but alters or modifies their natural dispositions. The dog, for example, when in a state of liberty, is a rapacious quadruped, and hunts and devours the weaker species: But, after he has submitted to the dominion of man, he relinquishes his natural ferocity, and is converted into a mean, servile, patient, and parasitical slave.

CHAPTER XVIII.

Of the Characters of Animals.

ON this subject it never was intended to paint the characters of every species, even of the larger animals. The reader will easily recollect, that, in many parts of this work, much has already been said with regard to the tempers, dispositions, and manners, of a great number of animals. These we shall not repeat, but proceed to some general remarks.

On every animal Nature has imprinted a certain *character*, which is indelibly fixed, and distinguishes the species. This character we discover by the actions, the air, the countenance, the movements, and the whole external appearance. The courage of the lion, the ferocity of the tiger, the voraciousness of the wolf, the pride of the courser, the dullness and indolence of the ass, the cunning and address of the fox, the affection and docility of the dog, the subtlety and selfishness of the cat, the mildness of the sheep, the timidity of the hare, the vivacity of the squirrel, are proper examples. These characters, when under the influence of domestication, may be modified by education, of which rewards and punishments are the chief instruments employed. But the original character, impressed by the hand of Nature, is never fully obliterated. Those animals which seem to have been destined by Nature to live in perpetual slavery under the dominion of man, have the mildest and most gentle dispositions. It is pleasant, but, at the same time, somewhat contemptible, to see a troop of oxen guided by the whip of a child.

In the human species, the variety of tempers, affections, aversions, and studies, is indispensibly necessary for supporting the social state, and carrying on the general business of life. Some minds are formed for study and deep research, and others for action, courage, and the exertion of bodily powers. The same variety in the dispositions and manners of the different tribes of animals is equally necessary for peopling the earth, and for supplying the reciprocal exigencies of its inhabitants.

Beside the general specific characters of animals, individual characters, especially among the human race, are strongly marked, and greatly variegated. In every government, and particularly in commercial states, human characters, independently of the original bias, or genius, stamped by Nature on individual minds, are often so disguised by a thousand artifices, that it requires not only time, but frequent interesting scenes, before a man can discover the real character even of an intimate companion. Many men associate together in the most harmonious manner, and show every symptom of friendship and attachment ; but, when any of them happens to be distressed, and to require aid, all this apparent friendship instantly vanishes, the aspect of the countenance, instead of exhibiting sympathy and cordiality, is converted into a cold reserve, and the unfortunate former companion is first shunned, and then deserted. This picture of human nature, we are sorry to remark, is too general ; but, thank Heaven, it is not universal ; for there always were, and still are, men of noble and generous minds, who willingly sacrifice part of their own interest to that of their friends.

With regard to the characters of quadrupeds, beside the specific dispositions which distinguish the different kinds, each individual possesses a peculiar character by which it may be discriminated from any other. These individual characters may be discovered not only by the aspect, but by the

actions of animals. Some dogs, even of the same race, are surly, churlish, and revengeful. Others are gay, frolicksome, and friendly. The countenances of men, which always indicate some part of their original and genuine character, are as various as their numbers. Though less subject to general observation, Nature has marked the countenances of every animal, even down to the insect tribes, with some characteristic strokes, which enable them to distinguish one another, and even to contract particular attachments. To us, the small birds, such as sparrows and linnets, appear to be so perfectly similar, that, though we had an opportunity of seeing great numbers of them collected in one place, it would require much time and attention to be enabled to make individual distinctions. After they have brought up their young, they associate promiscuously in flocks; but, when the genial spring arrives, a different scene is exhibited. The flocks disappear. Each male has selected, courted, and retired with a female to build a nest, to hatch eggs, and to nourish and support their young. If Nature had not stamped upon every individual a peculiar mark, it would be impossible that the immense multitudes who pair, or join in matrimony, should be capable of distinguishing and adhering faithfully to one another. A shepherd, who has been long accustomed to superintend a numerous flock, knows, by the countenances, and other natural or accidental marks, every individual. I knew a shepherd, who not only distinguished every individual of above two hundred sheep, but gave to each a particular name.

The characters of quadrupeds, and even of some birds, are indicated by obscure resemblances between the lineaments of their faces, and those of men of different features and dispositions. Some men, in the general expression of their countenances, resemble goats, others sheep, others oxen, others swine, others lions, others dogs, others foxes, others owls,

others hawks. Even in particular races of the same species, similarities of this kind may be traced. I know some men who resemble terriers, others greyhounds, others spaniels, others the shepherd's dog, others the lap-dog, &c. Some of these resemblances may be regarded as fanciful, and perhaps they frequently are. But, in general, when the resemblance to a particular animal is strongly marked in the human countenance, the dispositions of the men have a striking affinity to those of the animal. Men who resemble the fox are uniformly cunning and deceitful. Those who resemble the ox are dull, stupid, and phlegmatic. Those who resemble the lion are bold, open, generous, and witty. Those who resemble the cat are circumspect, designing, and avaricious. Those who resemble the greyhound are vigilant, active, and smart. Those who resemble the lap-dog are vain, presumptuous, petulant, and lascivious. Those who resemble the sow are disgusting both in their appearance and in their dispositions. Those who resemble a cross-made horse are cruel, unfeeling, and highly selfish. Those who resemble the spaniel, of whom the examples are numerous, are fawning, mean, and parasitical. Those who resemble the sheep are dull, timid, and inoffensive. Those who resemble the goat are fanciful, obstinate, and libidinous. Those who resemble a fine horse are intrepid, generous, tractable, and good humoured. Those who resemble a hawk are quick, desultory, and ingenious. Those who resemble the owl are dark, designing, and treacherous. Those who resemble the bee are active, ignorant, and industrious. It is needless to multiply examples. Every man's recollection and observation will furnish him with numberless coincidences between the similarities in structure and features to particular animals, and the form, dispositions, and manners, of the men who possess them.

Comparisons have been instituted, and analogies traced, between the structure, aspect, and dispositions, of some quad-

rupeds and those of certain birds, which show a uniformity in the general plan of Nature. Among birds, as well as quadrupeds, some species are carnivorous, and others feed upon fruits, grain, and various kinds of herbage. The eagle, which is a noble and a generous bird, represents the lion. The vulture, which is cruel and insatiable, represents the tiger. The kite, the buzzard, and the raven, who live chiefly on offals and carion, represent the hyaena, the wolf, and the jackal. The falcon, the sparrow-hawk, and other birds employed in hunting, represent the dog, the fox, the lynx, &c. The owl, who searches for her prey in the night, represents the cat. The heron and cormorant, who feed upon fishes, represent the beaver and the otter. Peacocks, hens, and all other birds which have a crop, or craw, represent oxen, sheep, goats, and other ruminating animals.

CHAPTER XIX.

Of the Principle of Imitation.

IMITATION necessarily implies some degree of intelligence. All animals, particularly those of the more perfect kinds, are endowed with the principle of imitation. The consequence is obvious, that all animals possess a certain portion of intellectual power. In man, the principle of imitation appears at a very early period of his existence. In the more advanced stages of life, this principle is so interwoven with other motives of acting and thinking, that it is difficult to distinguish it as a separate instinct, and equally difficult to conquer the habits and prejudices to which it has given rise. The less a man has cultivated his rational faculties, the more powerful is the principle of imitation over his actions and his habits of thinking. Most women, of course, are more influenced by the behaviour, the fashions, and the opinions of those with whom they associate than men. From this almost irresistible instinct, we should learn the extreme danger of frequenting the company of the dissolute and unprincipled; for bad habits are soon acquired, but very difficult to conquer. It is a comfortable circumstance, however, that if men, especially when young, are fortunate enough to fall in with the society of the virtuous and intelligent, the principle of imitation, so benevolent is Nature, acts with redoubled force. If we attend to our own feelings, we must acknowledge, that, in the acquisition of bad habits, there is an evident force upon our natural inclinations, but that, in virtuous associations, the mind acquiesces with pleasure, and feels no restraint in complying with the examples it perceives nor in acquiring the correspondent habits. We are prone to evil; but, when

not corrupted by improper imitations, Nature has made us much more prone to good.

Artificial language, which we learn entirely by imitation, distinguishes us, more than any other circumstance, from the brute creation. The proper use of it likewise forms the chief difference between one man and another ; for, by language, one man discovers a superiority of knowledge and of genius, while others express by it nothing but borrowed or confused ideas. In an idiot, or in a parrot, it marks only the most abject degree of stupidity. It shows the incapacity of either to produce a regular chain of thinking, though both of them be endowed with organs capable of expressing what passes within their minds. Men whose senses are delicate, and whose minds are easily affected, make the best actors, and the best mimics. Children, accordingly, are extremely alert in imitating the actions, the gestures, and the manners, of those with whom they associate. They are dexterous in perceiving ridiculous figures and representations, which they imitate with ease and propriety. Hence we perceive, in the education of children, the infinite importance of regulating the principle of imitation.

The education of the inferior animals, though short, is always successful. By imitation, they soon acquire all the knowledge possessed by their parents. They not only derive experience from their own feelings, but, by imitation, they learn and employ the experience of others. Young animals model their actions entirely upon those of the old. They see their seniors approach or fly when they perceive particular objects, hear particular sounds, or smell certain odours. At first, they approach or fly without any other determining principle but that of imitation. Afterwards, they approach or fly spontaneously, because they have then acquired the habit of approaching or flying, whenever they feel the same or similar sensations. Many instincts, as terror

upon hearing particular sounds, the appearance of natural enemies, the selection of food, &c. seem to be partly the effects of imitation. It is remarked by Ulloa, that, in the year 1743, the dogs in Juan Fernades had lost the faculty of barking. When associated with other dogs, it was with great difficulty that they again learned, by imitation to bark. The cause of these dogs loosing the expression of their usual language in a domestic state, it is not easy to investigate. Perhaps, by the aid of experience, and their own sagacity, they discovered that barking warned their prey to escape from danger. The jackals, however, who are considered as belonging to the dog-kind, not only hunt in packs, but, during the chase, make a loud and a hideous noise. Mr. White, in his Natural History of Selborne, a work which contains much information, and discovers a good and benevolent heart in the author, informs us, that he had an opportunity of seeing two dogs, a male and a female, which had been brought from Canton in China. These dogs, which, in China, are fattened for eating, are about the size of an ordinary spaniel, and are of a yellow colour. ‘When taken out into a field,’ he remarks, ‘the bitch showed some disposition for hunting, and dwelt ‘on the scent of a covey of partridges till she sprung them, ‘giving her tongue all the time. The dogs in South America are dumb ; but these bark much in a short thick manner, like foxes ; and have a surly savage demeanour, like ‘their ancestors, which are not domesticated, but bred up in ‘sties, where they are fed for the table with rice-meal, and ‘other farinaceous food. These dogs, having been taken ‘on board as soon as weaned, could not have learned ‘much from their dam ; yet they did not relish flesh when ‘they came to England. In the islands of the Pacific Ocean, ‘the dogs are bred upon vegetables, and would not eat flesh ‘when offered them by our circumnavigators.’

From facts of this kind, of which a great number might be mentioned, the following observations naturally arise. These Chinese dogs, though descended, probably for many generations, from a race of ancestors who never had the least experience or education in hunting, preserved their original instinct of scenting and pursuing game. The dog is a grossly carnivorous animal ; for he prefers carion to any other kind of nourishment ; yet the Chinese dogs discovered no particular relish for the flesh of animals. Thus it appears, that, by habits, acquired, not by the individual, but by a train of ancestors, both the taste and the constitution of animals may be greatly altered. From the same facts, however, it is equally evident, that Nature can never be entirely conquered. The moment the Chinese dogs first saw a field, they both scented and hunted game. Imitation and habit seem to have greater effects upon the mode of living, feeding, and the corporeal fabrick, than upon the original instincts of the mind. These dogs, even when they came to England after a long voyage, had not acquired the habit of greedily devouring, like other dogs, either fresh meat or carion ; but, on the first opportunity afforded to them, they discovered an inclination to hunt.

CHAPTER XX.

Of the Migration of Animals.

THE Hon. Daines Barrington, in his *Essay on the Periodical Appear and Disappearing of certain Birds, at different times of the year**, has, by many ingenious arguments, as well as curious facts, rendered it extremely probable, that no birds, however strong and swift in their flight, can possibly fly over such large tracts of the ocean as has been commonly supposed. He admits partial migrations or *flittings*, as he calls them, though he does not attempt to ascertain the distances of these flittings. With regard to the swallows, of which there are several species in Britain, some naturalists, of whom the Hon. Daines Barrington is one, are inclined to think that they do not leave this island at the end of autumn, but that they lie in a torpid state till the beginning of summer in the banks of the rivers, the hollows of decayed trees, the recesses of old buildings, the holes of sand-banks, and in similar situations. That swallows, in the winter months, have sometimes, though very rarely, been found in a torpid state, is unquestionably true. Neither is the inference, that, if any of them can survive the winter in that state, the whole of them may subsist, during the cold season, in the same condition, in the smallest degree unnatural. Still, however, the numbers of swallows which appear in this island, as well as in all parts of Europe, during the summer months, are so very considerable, that, if the great body of them did not migrate to some other climate, they should be much more frequently found in a torpid state. On the contrary, when a few of them are discovered in that state, it is regarded

* Phil. Transact, vol. 62, page 265, &c.

as a wonder even by the country people, who have the greatest opportunities of stumbling upon facts of this kind. When, accordingly, a few swallows or martins are found torpid in winter, and have been revived by a gentle heat, the fact, and few such facts there are, is carefully recorded as singular in all the periodical publications of Europe.

Mr. Pennant informs us, from undoubted authority, that some quails, and other birds which are generally supposed to leave this island in winter, retire to the sea-coasts, and pick up their food among the sea-weeds*.

'Quails,' Mr. Pennant remarks, 'are birds of passage; some entirely quitting our islands, others shifting their quarters. A gentleman, to whom this work lies under great obligations, has assured us, that these birds migrate out of the neighbouring inland counties, into the hundreds of Essex in October, and continue there all the winter: If frost or snow drive them out of the stubble-fields and marshes, they retreat to the sea-side, shelter themselves among the weeds, and live upon what they can pick up from the algae, &c. between high and low water mark. Our friend remarks, that the time of their appearance in Essex coincides with that of their leaving the inland counties †.'

A quail, it must be allowed, seems to be very much unqualified for a long migration; for its tail is short, the bird never rises more than twenty or thirty feet from the ground, and it seldom flies above three hundred yards at a time. Belon, however, an author of great sagacity and credit, tells us, that, in his passage from Rhodes to Alexandria, many, quails flying from north to south, were taken in his ship. From this circumstance, he remarks, 'I am persuaded that they shift places; for formerly, when I failed out of

* Brit. Zool. Vol. 1. page 210. 2d edit. 8vo.

† Pennant, *ibid.*

'the Isle of Zant to Morea, or Negropont, in the spring, I observed quails flying the contrary way, at which time, also, a great many were taken in our ship.' This traverse they might be enabled to accomplish by passing from one island to another in the Mediterranean.

Instances of swallows and some other birds alighting on the masts and cordage of vessels, at considerable distances from any shore, are not so numerous as might be expected. Neither have they been often observed flying over seas in great flocks. Mr. Peter Collinson, in a letter printed in the Philosophical Transactions, says, 'that Sir Charles Wager had frequently informed him, that, in one of his voyages home in the spring, as he came into soundings in our channel, a great flock of swallows almost covered his rigging ; that they were nearly spent and famished, and were only feathers and bones ; but, being recruited by a night's rest, they took their flight in the morning.'

M. Adanson, in his voyage, informs us, that, about fifty leagues from the coast of Senegal, four swallows settled upon the ship, on the sixth day of October ; that these birds were taken ; and that he knew them to be the true swallow of Europe, which he conjectures were then returning to the coast of Africa. The Hon. Daines Barrington, with more probability, supposes that these swallows, instead of being on their passage from Europe, were only flitting from the Cape de Verde islands to the continent of Africa, a much shorter flight, but to which they seemed to be unequal, as they were obliged, from fatigue, to light upon the ship, and fall into the hands of the sailors.

Swallows, Mr. Kalm remarks, appear in the Jerseys about the beginning of April. They are, on their first arrival, wet, because they have just emerged from the sea or lakes, at the bottom of which they had remained in a torpid state during the whole winter. But Mr. Kalm, who wishes to sup-

port the torpidity of swallows during the winter, likewise informs us, that he himself met with them at sea, nine hundred and twenty miles from any land*.

These, and similar facts, the Hon. Daines Barrington endeavours to explain, by supposing that birds discovered in such situations, instead of attempting to cross large branches of the ocean, have been forcibly driven from some coast by storms, and that they would naturally perch upon the first vessel which came within their view.

In Britain, five species of swallows appear in the summer and disappear in the winter. 1. The house-swallow makes its appearance about twenty days earlier than the martin, or any other of the swallow tribe. They are often seen about the 13th day of April. They disappear about the end of September. A few days previous to their departure, they assemble in great flocks on the tops of houses, churches, and trees, from whence they are supposed to take their flight. This unusual and temporary association of numbers indicates the impulse of some common instinct by which each individual is actuated. The house swallow is easily distinguished from the other species by the superior forkiness of its tail, and by a red spot on the forehead, and under the chin. This species build in chimneys, and make its nest of clay, but leaves the top quite open. 2. The martin is inferior in size to the former, and its tail is much less forked. The martins appear in Britain soon after the house-swallow. They build under the eaves of houses : The nest is composed of the same materials as those of the house-swallow ; but it is covered above, and a small hole only is left in the side for the ingress and egress of the birds. The martins totally disappear about the beginning of October. 3. The sand-martin, or bank-martin, is by much the smallest of the swallow-kind that visit Britain. The sand-martins arrive very

* Voy. tom. 1. page 24.

soon after the house-swallow, and disappear about Michaelmas. They dig considerable holes in sand-pits and in the banks of rivers, where they build their nests, which consist not of mud, like those of the former species, but of grasses and feathers laid together in a very slovenly manner. It is worthy of remark, that these birds do not employ the cavities they dig in summer for winter-quarters ; since sand-banks, so perforated, have been carefully searched in the winter, and nothing was found but empty nests*. 4. The swift, or black martin of Willoughby, is the largest of our swallows, and is the latest of arriving in this country ; for the swifts are seldom seen till the beginning of May, and commonly appear, not in flocks, but in pairs. Swifts, like the sand-martins, carry on the business of incubation in the dark. They build in the cranies of castles, towers, and steeples. Straw and feathers are the materials they use. They disappear very early ; for they are almost never seen after the middle of August. 5. The goat sucker, which belongs to the swallow tribe, is likewise a bird of passage. Like the other swallows, it feeds upon winged insects. But, instead of pursuing its prey during the day, it flies only in the night, and seizes moths, and other nocturnal insects. From this circumstance, it has not improperly received the appellation of the *nocturnal swallow*. The goat-sucker stays only a short time in Britain. It appears not till about the end of May, and retires in the middle of August. It lays its eggs, which are commonly two, and sometimes three, on the bare ground.

To give catalogues of the numerous birds of passage which frequent this island, as well as other countries, and to mark the times of their arrival and departure, would be deviating entirely from our plan. For circumstances of this kind, the curious may consult Catesby, Klein, Linnaei *Amoenitates Academicae*, White, &c. But, as the periodical appearance

* White's Natural History of Selborne, page 177.

and disappearance of the swallow-tribe have given rise to different theories and opinions, we shall briefly relate those opinions, and conclude with some remarks on migration in general.

Herodotus and Prosper Alpinus mention one species of swallow which resides in Egypt during the whole year*; and Mr. Loten, late governour of Ceylon, assured Mr. Pennant, that those of Java never remove. If these be excepted, all the other known kinds retreat or migrate periodically. Swallows migrate from almost every climate. They remove from Norway †, from North America ‡, from Kamtschatka§, from the temperate parts of Europe, from Aleppo ||, and from Jamaica ¶.

Concerning the periodical appearance and disappearance of swallows, there are three opinions adopted by different naturalists. The first and most probable, is, that they remove from climate to climate at those particular seasons when winged insects, their natural food, fails in one country or district and abounds in another, where they likewise find a temperature of air better suited to their constitutions. In support of this opinion, we have the testimony, as formerly mentioned, of Sir Charles Wager, of M. Adanson, and of many navigators. It is equally true, however, that some species of swallows have been occasionally found in a torpid state during winter. Mr. Collinson gives the evidence of three gentlemen who were eye-witnesses to a number of sand-martins being drawn out of a cliff on the Rhine in the Month of March 1762**. The Hon. Daines Barrington, in the year 1768, communicated to Mr. Pennant, on the authority of the late Lord Belhaven, the following fact: 'That

* Prosp. Alp. tom. 1, page 198.

† Pontopp. Hist. Norw. ii. 98. ‡ Catesby's Carol. v. 1. page 51. App. 8.

§ Hist. Kamtschatka, page 162. || Russel's Alep. page 70. ¶ Phil. Trans. No. 36.

** Philosoph. Transact. vol. 53, page 101. art. 24.

‘ numbers of swallows have been found in old dry walls, and in sand-hills, near his Lordship’s seat in East Lothian ; not once only, but from year to year ; and that, when they were exposed to the warmth of a fire, they revived*.’ These, and other facts of the same kind, seem to be uncontrovertible ; and Mr. Pennant infers from them, that ‘ we must divide our belief relating to these two so different opinions, and conclude, that one part of the swallow tribe migrate, and that others have their winter-quarters near home †.’ But we should rather incline to think, with those naturalists who suppose that the torpid swallows which are occasionally, though very rarely, discovered in the winter season, have been obliged to remain behind, because they were too young, weak, diseased, or superannuated, to undertake a long and fatiguing flight. Still, however, that the torpidity of the feathered tribes should be solely confined to the swallows, is a very singular fact in the history of Nature. Among quadrupeds, there are many species who lie in a dormant or torpid state during winter. But, if the swallow be excepted, not a single species of birds, notwithstanding the great numbers which, at stated times, appear and disappear in every corner of the globe, has ever been discovered in that state. This circumstance alone, though we cannot yet ascertain the precise places to which different species of birds of passage resort, is a most convincing proof of migration in general.

It has been asserted, and even believed, by some naturalists, that swallows pass the winter immersed under the ice, at the bottom of lakes, or beneath the waters of the sea. Olaus Magnus, Archbishop of Upsal, seems to have been the first who adopted this opinion. He informs us, that swallows are found in great clusters at the bottoms of the northern

* Pennant’s British Zoology, vol. 2. page 250. 8vo edit.

† Ibid. 251.

lakes, with mouth to mouth, wing to wing, foot to foot, and that in autumn they creep down the reeds to their subterraneous retreats*. ‘That the good Archbishop,’ Mr. Pennant archly remarks, ‘did not want credulity in other instances. ‘appears from this, that, after having stocked the bottoms ‘of the lakes with birds, he stores the clouds with mice, ‘which sometimes fall in plentiful showers on Norway and ‘the neighbouring countries!’ Klein has endeavoured to support the notion that swallows lie under water during the winter, and gives the following account of their manner of retiring, which he collected from some countrymen : They asserted, he tells us, that the swallows sometimes assembled in numbers on a reed till it broke and sunk them to the bottom : That their immersion was preceded by a kind of dirge, which lasted more than a quarter of an hour : That others united, laid hold of a straw with their bills, and plunged down in society : That others, by clinging together with their feet, formed a large mass, and in this manner committed themselves to the deep†.

Two reasons seem to render this supposed submersion of swallows impossible. In the first place, no land-animal can exist so long without some degree of respiration. The otter, the seal, and water-fowls of all kinds, when confined under the ice, or entangled in nets, soon perish ; yet it is well known, that animals of this kind can remain much longer under water than those who are destitute of that peculiar structure of the heart which is necessary for any considerable residence beneath that penetrating element. Mr. John Hunter, in a letter to Mr. Pennant, informs us, ‘That he had dissected many swallows, but found nothing in them different from other birds as to the organs of respiration : That all those animals which he had dissected of the class that

* Derham’s Phys. Theol. page 349.

† Klein Prod. Hist. Avium, page 205. 206.

' sleep during winter, such as lizards, frogs, &c. had a very different conformation as to those organs : That all those animals, he believes, do breathe in their torpid state ; and, as far as his experience reaches, he knows they do ; and that, therefore, he esteems it a very wild opinion, that terrestrial animals can remain any long time under water without drowning.' Another argument against their submersion rises from the specific gravity of the animals themselves. Of all birds, the swallow tribes are perhaps the lightest. Their plumage, and the comparative smallness of their weight, indicate that Nature destined them to be almost perpetually on the wing in quest of food. From this specific lightness, the submersion of swallows, and their continuing for months under water, amount to a physical impossibility. Even water-fowls, when they wish to dive, are obliged to rise and plunge with considerable exertion, in order to overcome the resistance of the water. Klein's idea of swallows employing reeds and straws as means of submersion is rather ludicrous ; for these light substances, instead of being proper instruments for assisting them to reach the bottom, would infallibly contribute to support them on the surface, and prevent the very object of their intention. Besides, admitting the possibility of their reaching the bottom of lakes and seas, and supposing they could exist for several months without respiration, what would be the consequence ? The whole would soon be devoured by otters, seals, and fishes of various kinds. Nature is always anxious for the preservation of species. But, if the swallow tribes were destined to remain torpid, during the winter months, at the bottom of lakes and seas, she would act in opposition to her own intentions ; for, in a season or two, the whole genus would be annihilated.

Mr. White of Selborne has favoured us with the following information concerning the migration of swallows : ' If

'ever I saw,' says he, 'any thing like actual migration, it
'was last Michaelmas day, 1768. I was travelling, and out
'early in the morning: At first there was a vast fog; but,
'by the time that I was got seven or eight miles from home
'towards the coast, the sun broke out into a delicate warm
'day. We were then on a large heath or common, and I
'could discern, as the mist began to break away, great num-
'bers of swallows clustering on the stinted shrubs and bush-
'es, as if they had roosted there all night. As soon as the
'air became clear and pleasant, they all were on the wing at
'once, and, by a placid and easy flight, proceeded on south-
'ward towards the sea: After this I did not see any more
'flocks, only now and then a straggler. When I used to
'rise in a morning last autumn, and see the swallows and
'martins clustering on the chimneys and thatch of the neigh-
'bouring cottages, I could not help being touched with se-
'cret delight, mixed with some degree of mortification:
'With delight, to observe with how much ardour and punc-
'tuality those poor little birds obeyed the strong impulse to-
'wards migration, or hiding, imprinted on their minds by
'their great Creator; and with some degree of mortifica-
'tion, when I reflected, that, after all our pains and enquir-
'ies, we are yet not quite certain to what regions they do
'migrate; and are still farther embarrassed to find, that
'some do not actually migrate at all*.'

In another part of this work, Mr. White says: 'But we
'must not deny migration in general; because migration
'certainly does subsist in some places, as my brother in *An-*
'*dalusia* has fully informed me. Of the motions of these
'birds he has ocular demonstration, for many weeks toge-
'ther, both spring and fall: During which periods, myriads
'of the swallow kind traverse the Straits from north to south,
'and from south to north, according to the season. And

* White's Natural History of Selborne, page 64. 65.

' these vast migrations consist not only of *birudines* (swallows,)
' but of *bee birds*, *hoopoes*, *oropendulos*, or *golden thrushes*, &c. &c.
' and also many of our *soft billed summer birds of passage*; and,
' moreover, of birds which never leave us, such as all the
' various sorts of hawks and kites. Old Belon, two hundred
' years ago, gives a curious account of the incredible armies
' of hawks and kites, which he saw in the spring-time trav-
' ersing the Thracian Bosphorus from Asia to Europe. Be-
' sides the above mentioned, he remarks, that the procession
' is swelled by whole troops of eagles and vultures*.'

Mr. White likewise, with much propriety, remarks, that our inquiries concerning the migration of birds have been too much confined to the swallow tribes; while little attention has been paid to the short-winged birds of passage, such as quails, red-starts, nightingales, white-throats, black-caps, &c. All these, though seemingly ill qualified for long flights, disappear in the winter, and not one of them, notwithstanding their immense numbers, has ever been found in a torpid state.

To mark the times of the arrival and departure of birds of passage in different countries, and in different districts of the same countries, and the probable motives arising from the state of the country with regard to heat and cold, and to that of the food peculiar to each kind, would throw much light upon the history of migration. To Mr. White of Selborne we are obliged for the following lists of birds of passage which he has observed in his neighbourhood. These lists are arranged nearly in the order of time.

* White's Natural History of Selborne, page 139.

List of Summer Birds of Passage.

NAMES.	USUALLY APPEAR ABOUT
1. Wryneck,	Middle of March.
2. Smallest willow-wren,	March 23.
3. House-swallow,	April 13.
4. Martin,	Ibid.
5. Sand-Martin,	Ibid.
6. Black-cap,	Ibid.
7. Nightingale,	Beginning of April.
8. Cuckoo,	Middle of April.
9. Middle willow-wren,	Ibid.
10. White-throat,	Ibid.
11. Red-start,	Ibid.
12. Stone-curlew,	End of March.
13. Turtle-dove,	
14. Grasshopper-lark,	Middle of April.
15. Swift,	April 27.
16. Less reed-sparrow,	
17. Land-rail,	
18. Largest willow-wren,	End of April.
19. Goat-sucker, or fern-owl,	Beginning of May.
20. Fly-catcher,	{ May 12. This is the latest summer bird of passage.

Most soft-billed birds feed upon insects, and not on grain or seeds ; and, therefore, they retire before winter. But the following soft-billed birds, though they eat insects, remain with us during the whole year ; such as the red-breast and wren, who frequent out-houses and gardens during the winter, and eat spiders, &c. ; the hedge-sparrow, who frequents sinks for crumbs and other sweepings ; the white wagtail, the yellow-wagtail, and the gray wagtail, who frequent shallow rivulets near the spring heads, where the water seldom

freezes, and feed upon the aureliae of insects; the wheatear, some of which are to be seen during the winter, &c.

List of Winter Birds of Passage in the neighbourhood of Selborne.

1. The ring-ousel. This bird appears about Michaelmas week, and is a new migration lately discovered by Mr. White.

2. The red-wing, or wind-thrush, appears in Britain about old Michaelmas. They come in great flocks from the frozen regions of the north.

3. Field-fare. These birds visit Britain in immense numbers about Michaelmas, and depart about the end of February, or the beginning of March. They pass the summer in the northern parts of Europe, and likewise in Lower Austria*. They breed in the largest trees, feed on berries of all kinds†, but prefer those of the juniper. It is probable that the field-fares which migrate into Britain come from Norway and the northern regions of Europe, because we find that they both breed and winter in Prussia, Austria‡, and the more temperate climates.

4. The Royston-crow, or hooded crow of our countryman Sir Robert Sibbald, is likewise a bird of passage. It visits us in the beginning of winter, and departs with the wood-cocks. They frequent the inland as well as the maritime parts of Britain. When near the coasts, they feed upon crabs, muscles, and other shell-fishes. They breed in Sweden, build their nests in trees, and lay four eggs||. They likewise breed in the southern parts of Germany, and particularly on the banks of the Danube ¶.

5. The wood-cock appears in this country about old Michaelmas. During the summer, wood-cocks inhabit the Alps**, Norway, Sweden††, and the northern parts of Eu-

* Kramer Elench. page 361. † Linn. Faun. Succ. sp. 78.

‡ Klein Hist. Avium. page 178.

|| Linn. Faun. Succ. sp. 88. ¶ Kramer, page 333.

** Willoughby's Oraithology, page 290.

†† M. de Geer's and Dr. Wallerius's letters to Mr. Pennant.

rope. From these countries they retire as soon as the frost commences, which obliges them to migrate into milder climates, where the soil is open, and more adapted to their mode of feeding; for they live on worms, which they search for with their long bills in soft and moist grounds in the midst of woods. Wood-cocks, taking the advantage of the night, or of foggy weather, arrive here in flocks: But they soon separate; and, before returning to their summer quarters, they pair. They fly and feed during the night. They begin their flight in the evening, and return to their retreats in the glades when day commences. They depart from Britain about the end of February or the beginning of March. Some of them, however, like the straggling swallows, have been known to breed, and to remain here during the whole year*. It is likewise known that wook-cocks migrate from France, Germany, and Italy, and that they make choice of cold northern climates for their summer residence. About the end of October they visit Burgundy, but remain there four or five weeks only; because it is a dry country, and, on the first frosts, they are obliged to retire for want of sustenance. In the winter, they are found as far south as Smyrna, Aleppo†, and Barbary‡. They are even very common in Japan ||.

6. The snipe. Snipes are enrolled as birds of passage by Mr. White, though he acknowledges that some of them constantly breed in England. ‘In winter,’ Mr. Pennant remarks, ‘snipes are very frequent in all our marshy and wet grounds, where they lie concealed in the rushes, &c. In the summer, they disperse to different parts, and are found in the midst of our highest mountains, as well as our low moors. Their nest is made of dried grass. They lay four eggs of a dirty olive colour, marked with dusky spots.

* Pennant’s British Zoology, vol. 2. page 349. 8vo.

† Russel’s History of Aleppo, page 64. ‡ Shaw’s Travels, page 253.

|| Kaempfer’s Hist. Japan, vol. 1. page 129.

‘ Their young are so often found in England, that we doubt whether they ever entirely leave this island*.

7. The jack-snipe. This bird, which is very common in Scotland, and frequents the banks of rivers and lakes, is ranked by Mr. White as a winter bird of passage, without mentioning either the time of its arrival or departure ; and Mr. Pennant is entirely silent on the subject†.

8. The wood-pigeon. Mr. White, without mentioning either the time of their appearing or disappearing, tells us, that ‘ they seldom appear till late ; nor in such plenty as formerly‡.’

9. The wild-swan. During hard winters, this bird frequents the coasts of Britain in large flocks ; but, from any information we have been able to obtain, it does not breed in our island. Martin, in his History of the Hebrides, or Western Isles||, informs us, that wild swans arrive in great numbers in Lingey, one of the Hebrides, in the month of October, and remain there till March, when they retire more northward to breed. For this purpose, the swans like most other water-fowls, prefer such places as are least frequented by mankind. During summer, the lakes, marshes, and forests of Lapland are filled with myriads of water-fowls. In that northern region, swans, geese, the duck tribe, goosanders, divers, &c. pass the summer ; but in autumn they return to us, and to other more hospitable shores§.

10. The wild-goose. The wild geese, it is probable, breed in the retired regions of the north. They arrive here in the beginning of winter, and frequently feed on our corn grounds. They fly at a great height, and observe regulari-

* Pennant’s British Zoology, vol. 2. page 358. 8vo.

† White’s Natural History of Selborne, page 117. ; and Pennant’s British Zoology, vol. 2. page 359. 8vo.

‡ White’s Natural History of Selborne, page 117.

|| Description of the Western Isles, page 71.

§ Linn, Flora Lapponica, page 273. Oeuvres de Maupertuis, tom. 3. page 141.

ty in their movements. They sometimes form a straight line ; and, at others, they assume the shape of a wedge, which facilitates their progress through the resisting air.

With regard to the wild-duck, pochard, wigeon, and teal, though Mr. White places them in the list of birds of passage, he does not mention either the times of their arrival or departure. Though it be probable that most of the duck-kind migrate, yet it is certain, that some individuals of different species of them breed in this country, and continue in it during the whole year. As to the duck-kind in general, Mr. Pennant remarks : ‘ Of the numerous species that form this genus, we know of no more than five that breed here. The tame swan and tame goose, the *Shield duck*, the *eider duck*, and a very small portion of the *wild ducks*. The rest contribute to form that amazing multitude of water fowl that annually repair from most parts of Europe to the woods and lakes of Lapland, and other Arctic regions*, there to perform the functions of incubation and nutrition in full security. They and their young quit their retreat in September, and disperse themselves over Europe. With us they make their appearance the beginning of October, circulate first round our shores, and when compelled by severe frost, betake themselves to our lakes and rivers†.’

In winter, the bernacles, or brent-ducks, appear in vast flocks on the north-west coasts of Britain. They are very shy and wild ; but, when taken, they soon grow as familiar as our domestic ducks. They leave the British shores in February, and migrate as far as Lapland, Greenland, and even Spitsbergen‡.

The solan-geese, or gannats, are likewise birds of passage. They frequent the isle of Ailsay, near the Frith of Clyde ;

* Collect. Voyag. Dutch East India Company, 8vo. 1703. page 19. Clusi Exot. page 368.

† Pennant’s British Zoology, vol. 2. page 519. 520.

‡ Linn. Amoen. Acad. tom. 4. page 585. Barent’s Voyage, page 19.

the rocks adjacent to St. Kilda, the most remote of the Hebrides ; the Skelig isles, off the coast of Kerry ; and the Bass isle in the Frith of Fourth. The multitudes which frequent these places are prodigious. To give an idea of their numbers, the reader will not be displeased to see Dr. Harvey's short account of the Bass. ' There is a small island in the Frith of Fourth, called the *Bass Island*, which does not exceed one mile in circumference. The surface of this island, during the months of May and June, is so entirely covered with nests, eggs, and young birds, that it is scarcely possible to walk without treading on them. The flocks of birds on the wing are so prodigious, that they darken the air like clouds, and their noise is so great, that a man cannot without difficulty hear his neighbour's voice. If, from the top of the precipice, you look down upon the sea, you will see it on every side covered with infinite numbers of birds of different kinds, swimming about and hunting for their prey. When sailing round the island, if you survey the hanging cliffs, you will perceive, in every cragg, or fissure of the rocks, innumerable birds of various kinds, more than the stars of heaven in a serene night. If you view the distant flocks, either flying to or from the island, you will imagine them to be a vast swarm of bees*.' The rocks of St. Kilda seem to be equally frequented by solan geese ; for Martin, in his description of the Hebrides, informs us, that the inhabitants of this small island consume annually no less than 22,600 young birds of this species, beside an amazing number of their eggs. The solan geese and their eggs constitute the chief food of these islanders. They preserve both the fowls and the eggs in small pyramidal stone buildings, which, to protect the food from moisture, they cover with the ashes of turf. The solan geese are birds of passage. Their first appearance is in March, and they continue till

* Hervey de Generat. Animal. Exercit. II.

August or September. But, in general, the times of their breeding and departure seem to coincide with the arrival of the herring, and the migration of that fish from our coasts. It is more than probable that these birds attend the herrings and pilchards during their whole circuit round the British islands; for the appearance of the solan geese is always esteemed by the fishermen as a certain presage of the approach of the herrings or pilchards. In quest of food, these birds migrate as far south as the mouth of the Tagus; for they are frequently seen off Lisbon during the month of December.

The cross-beak, the cross-bill, and the silk-tail, are likewise enumerated by Mr. White as birds of passage. ‘But these,’ says he, ‘are only wanderers that appear occasionally, and are not observant of any regular migration*.’

The long-legged plover, and sanderling, visit us in winter only; and it is worthy of remark, that every species of the curlews, wood-cocks, sand-pipers, and plovers†, which forsake us in the spring, retire to Sweden, Poland, Prussia, Norway, and Lapland, both to feed and to breed. They return to us as soon as the young are able to fly; because the frosts, which set in early in these countries, totally deprive them of the means of subsistence. For the same reason they leave us in summer, as the dryness and hardness of the ground prevent them from penetrating the earth with their bills in quest of worms, which constitute the natural food of these birds.

From the facts which have been enumerated, and from others of a similar nature, it is evident, that many birds, both of the land and water kinds, migrate from one climate to another. But, even in the same climate and country, birds occasionally perform partial migrations. During hard winters, when the surface of the earth is covered with snow,

* White’s Natural History of Selborne, page 118.

† Linn. Amoen. Acad. tom. 4. page 588. Klein de Avium Migrat. page 187.

many birds, as larks, snipes, &c. retire from the inland parts of the country to the sea-shores, where they pick up a scanty subsistence. Others, as the wren, the red-breast, and many of the small birds, or sparrow-kind, resort to gardens, and the habitations of men. Their intention, it is obvious, is to procure food and shelter.

There are three principle objects of migration : Food, temperature of air, and convenient situations for breeding. Such birds as migrate to great distances are alone denominat-ed *birds of passage*. But all birds are, in some measure, birds of passage, though they do not migrate to places so remote from their former abodes. At particular times of the year, most birds migrate from one county to another, or from the more inland districts toward the shores. These partial migrations of small birds are well known to bird-catchers, who make a livelihood by ensnaring them into their nets, and selling them. The birds *fly*, as the bird-catchers term it, about the end of September, and during the months of October and November. There is another, but less considerable, flight in March. Some begin their flight annually about Michaelmas ; others, as the wood-larks, succeed, and continue their flight till the middle of October ; but the green-finches does not migrate till the frost obliges it to remove in quest of food and shelter. These partial migrations, or flittings, are performed from day-break till noon. Another, but smaller, flight commences at two o'clock, and continues till night approaches. The times when particular birds migrate from one situation to another are well known to the bird-catchers, who, by means of call-birds, nets, and other devices, seize great numbers of them, and, after accustoming them for some time to restraint and slavery, sell them, for considerable prices, to curious men and whimsical women. A diligent attention to these partial migrations, and their

motives, would soon unfold the causes of those of a more extensive kind.

Migration is generally supposed to be peculiar to the feathered tribes. This is a limited idea, which has originated from inattention to the oeconomy of Nature. Birds migrate with a view to remedy the inconveniences of their present situation, and to acquire a more commodious station with regard to food, temperature, generation, and shelter. From similar motives, men, sometimes in amazing multitudes, have migrated from north to south, displaced the native inhabitants, and fixed establishments in more comfortable climates than those which they had relinquished. These, in their turn, have fallen victims to fresh and barbarous emigrants. Among the inhabitants of the more northern nations, as Norway, Sweden, Scotland, &c. notwithstanding a very strong attachment to their native countries, there seems to be a natural or instinctive propensity to migrate. Poverty, the rigour of climate, curiosity, ambition, the false representations of interested individuals, the oppression of feudal barons, and similar circumstances, have of late given rise to great emigrations of the human species. But, it is worthy of remark, that the emigrations from south to north, except from the love of conquest in ambitious nations, are so rare, that the instinct seems hardly to exist in those more fortunate climates. Curiosity is a general instinctive principle, which operates strongly in the youthful periods of life, and stimulates every man to visit places that are distant from his ordinary residence. This innate desire is influenced by the relations of travellers, and by many other incentives of a more interested kind. Without the principle of migration, mankind, it is probable, would never have been so universally diffused over the surface of the earth. It is counterbalanced, however, by attachment to those countries which gave us birth, a principle still more powerful and efficient. Love of our native

country is so strong, that, after gratifying the migrating principle, almost every man feels a longing desire to return.

Savages, as long as their store of food remains unexhausted, continue in a listless inactive state. They exhaust many days sitting in perfect indolence, and seem not to be prompted by any motives of curiosity. They have not a conception of a man's walking either for amusement or exercise. But, when their provisions begin to fail, an astonishing reverse takes place. They then rouse as from a profound sleep. In quest of wild beasts, birds, and fishes, they migrate to immense distances, exert the greatest feats of activity, and undergo incredible hardships and fatigue. After acquiring a store of provisions, they return to their wonted haunts, and remain inactive till their food again begins to fail.

Quadrupeds likewise perform partial migrations. At the approach of winter, the stag, the reindeer, and the roebuck, leave the tops of the lofty mountains, and come down to the plains and copses. Their chief objects, in these flittings, are food and shelter. When summer commences, they are harassed with different species of winged insects, and, to avoid these enemies, they regain the summits of the mountains, where the cold and the height of the situation protect them from the attacks of the flies. In Norway, and the more northern regions of Europe, the oxen, during the winter, migrate to the shores of the sea, where they feed upon sea-plants and the bones of fishes ; and Pontoppidan remarks, that the cattle know by instinct when the tide retires, and leaves these articles of food upon the shore. In Orkney and Shetland, the sheep in winter, for the same purposes, uniformly repair to the shore at the ebbing of the tides. Rats, particularly those of the northern regions of Europe, appear, from time to time, in such myriads, that the inhabitants of Norway and Lapland imagine the animals fall from

heaven. The celebrated Linnaeus, who paid great attention to the oeconomy of these migrating rats, remarked, that they appeared in Sweden periodically every eighteen or twenty years. When about to migrate, they leave their wonted abodes, and assemble together in numbers inconceivable. In the course of their journey, they make tracks in the earth of two inches in depth ; and these tracks sometimes occupy a breadth of several fathoms. What is singular, the rats, in their march, uniformly pursue a straight line, unless they are forced to turn aside by some unsurmountable obstacle. If they meet with a rock, they first try to pierce it, and, after discovering the attempt to be impracticable, they go round it, and then resume the straight line. Even a lake does not interrupt their passage ; for they either traverse it in a straight line or perish in the attempt ; and, if they meet with a bark or other vessel, they do not alter their direction, but climb up the one side of it and descend by the other.

Frogs, immediately after their transformation from the tadpole state, leave the water, and migrate to the meadow or marshy grounds in quest of insects. The numbers of young frogs which suddenly make their appearance in the plains induced Rondeletius, and many other naturalists, to imagine that they were generated in the clouds and showered down upon the earth. But if, like the worthy and intelligent Mr. Derham, they had examined the situation of the place with regard to stagnating waters, and attended to the nature and transformation of the animals, they would soon have discovered the real cause of the phenomenon.

Of all migrating animals, particular kinds of fishes make the longest journeys, and in the greatest numbers. The multiplication of the species, and the procuring of food, are the principal motives of the migration of fishes. The salmon, a fish which makes regular migrations, frequents the northern regions alone. It is unknown in the Mediterranean sea, and in the rivers which fall into it both from Europe and Africa.

It is found in some of the rivers of France that empty themselves into the ocean*. Salmons are taken in the rivers of Kamtschatka†, and appear as far north as Greenland. Salmons live both in the ocean, and in fresh waters. For the purpose of depositing their spawn, they quit the sea in the month of September, and ascend the rivers. So strong is the instinct of migrating, that they press up the rivers with amazing keenness, and scarcely any obstacle is sufficient to interrupt their progress. They spring, with great agility, over cataracts of several feet in height. In their leaps, they spring straight up with a strong tremulous motion, and do not, as has been vulgarly supposed, put their tails in their mouths. When they find a place which they think proper for depositing their eggs, the male and female unite their labours in forming a convenient receptacle for the spawn in the sand, which is generally about eighteen inches deep. In this hole the female deposits her eggs, and the mothers milt, which they are said to cover carefully with their tails; for, after spawning, their tails are deprived of skin. The eggs, when not disturbed by violent floods, lie buried in the sand till the spring, and they are hatched about the end of March. The parents, however, after this important office has been performed, hasten back to the sea, in order to cleanse themselves, and to recover their strength. Toward the end of March, the young fry begin to appear, and they gradually increase in size till they acquire the length of four or five inches, and are then called *smelts*, or *smoults*‡. About the beginning of May, all the considerable rivers of Scotland are full of salmon-fry. After this period, they migrate to the Sea. About the middle of June, the earliest of the fry begin to appear again in the rivers. At that time they are

* Rondelet. de Fluviat. page 167.

† Hist. Kamtschatka, page 143.

‡ See an account of the Salmon Fishery on the river Tweed, communicated to Mr. Pennant by Mr. Potts, Brit. Zool. vol. 3. page 241, 8vo. edit.

from twelve to sixteen inches long, and gradually augment, both in number and size, till about the end of July or beginning of August, when they weigh from six to nine pounds. This is a very rapid growth. But a gentleman of credit at Warrington informed Mr. Pennant of a growth still more rapid. A salmon, weighing seven pounds and three quarters, was taken on the seventh day of February. It was marked on the back, fin, and tail, with scissars, and then turned into the river. It was retaken on the 17th day of the following month of March, and then it weighed seventeen pounds and a half. The season for fishing salmon in the Tweed begins on the 30th of November, and ends on old Michaelmas day. In that single river, it is computed that no less than 208000, at a medium, are annually caught, which, together with the products of many other rivers on both sides of Scotland, not only afford a wholesome and palatable food to the inhabitants, but form no inconsiderable article of commerce.

Herrings are likewise actuated by the migrating principle. These fishes are chiefly confined to the northern and temperate regions of the globe. They frequent the highest latitudes, and are sometimes found on the northern coasts of France. They appear in vast shoals on the coast of America, as far south as Carolina. In Chesapeake bay there is an annual inundation of herrings; and Mr. Catesby informs us, that they cover the shores in such amazing numbers as to become offensive to the inhabitants. The great winter rendezvous of the herrings is within, or near the Arctic Circle, where they remain several months, and acquire strength after being weakened by the fatigues of spawning, and of a long migration. In these seas, insect food is much more abundant than in warmer latitudes. They begin their migration southward in the spring, and appear off the Shetland islands in the months of April and May. These, however, are only the forerunners

of the immense shoal which arrives in June. Their approach is recognised by particular signs, such as the appearance of certain fishes, the vast number of birds, as gannets or solan geese, which follow the shoal to prey upon the herrings. But when the main body arrives, its breadth and depth are so great as to change the appearance of the ocean itself. The shoal is generally divided into columns of five or six miles in length, and three or four in breadth. Their progressive motion creates a kind of rippling or small undulations in the water. They sometimes sink and disappear for ten or fifteen minutes, and then rise again toward the surface. When the sun shines, a variety of splendid and beautiful colours are reflected from their bodies. In their progress southward, the first interruption they meet with is from the Shetland islands. Here the shoal divides into two branches. One branch skirts the eastern, and the other the western shores of Great Britain, and fill every bay and creek with their numbers. Those which proceed to the west from Shetland, after visiting the Hebrides, where the great fishery is carried on, move on till they are again interrupted by the north of Ireland, which obliges them to divide a second time. One division takes to the west, where they are scarcely perceived, being soon lost in the immensity of the Atlantic Ocean. The other division goes into the Irish sea, and affords nourishment to many thousands of the human race. The chief object of herrings migrating southward is to deposit their spawn in warmer and more shallow seas than those of the Frigid Zone. This instinct seems not to be prompted by a scarcity of food; for, when they arrive upon our coasts, they are fat and in fine condition; but, when returning to the ocean, they are weak and emaciated. They continue in perfection from the end of June to the beginning of winter, when they begin to deposit their spawn. The great stations of the herring fisheries are off the Shetland and the western islands, and along the coast of Norfolk.

Beside salmons and herrings, there are many fishes which observe a regular migration, as mackerels, lampreys, pilchards, &c. About the middle of July, the pilchards which are a species of herrings, though smaller, appear in vast shoals off the coasts of Cornwall. When winter approaches, like the herrings, they retire to the Arctic seas. Though so nearly allied to the herring, it is not incurious to remark, that the pilchards, in their migration for the purpose of spawning, choose a warmer latitude ; for, off the coast of Britain, the great shoals never appear farther north than the county of Cornwall and the Scilly islands. Dr. Borlase, in his history of Cornwall, gives the following account of the pilchard fishery : ‘ It employs,’ says he, ‘ a great number of men on the sea, training them thereby to naval affairs ; employs men, women, and children, at land, in salting, pressing, washing, and cleaning, in making boats, nets, ropes, casks, and all the trades depending on their construction and sale. The poor is fed with the offals of the captures, the land with the refuse of the fish and salt ; the merchant finds the gains of commission and honest commerce, the fisherman the gains of the fish. Ships are often freighted hither with salt, and into foreign countries with the fish, carrying off, at the same time, part of our tin. The usual produce of the number of hogsheads exported each year, for ten years, from 1747 to 1756 inclusive, from the four ports of Tawy, Falmouth, Penzance, and St. Ives, it appears, that Tawy has exported yearly 1732 hogsheads ; Falmouth, 14631 hogsheads and two thirds ; Penzance and Mounts-Bay, 12149 hogsheads and one third ; St. Ives, 1282 hogsheads : In all amounting to 29795 hogsheads. Every hogshead, for ten years last past, together with the bounty allowed for each hogshead exported, and the oil made out of each hogshead, has amounted, one year with another at an average, to the price of one pound thirteen shillings and three pence ; so

* that the cash paid for pilchards exported has, at a medium, annually amounted to the sum of L. 49532 : 10 : 0.'

Of the land-crab there are several species. The migration of what is called the *violet land-crab* deserves some notice. It inhabits the warmer regions of Europe : But its particular residence is in the tropical climates of Africa and America. Land-crabs generally frequent the mountainous parts of the country, which are, of course, most remote from the sea. They inhabit the hollows of old trees, the clefts of rocks, and holes which they themselves dig in the earth. They are extremely numerous. In the months of April and May, they leave their retreats in the mountains, and march in millions to the sea-shore. At this period the whole ground is covered with them ; and a man can hardly put down his foot without treading on them*. The object of their migration is to deposit their spawn on the sea-shore. In their progress towards the sea, like the northern rats, the land-crabs move in a straight line. Even when a house intervenes, instead of deviating to the right or left, they attempt to scale the walls. But, when they meet with a river, they are obliged to wind along the course of the stream. In their migration from the mountains, they observe the greatest regularity and commonly divide into three battalions or bodies. The first consists of the strongest and boldest males, who, like pioneers, march forward to clear the route, and to face the greatest dangers. The females, who form the main body, descend from the mountains in regular columns, which are fifty paces broad, three miles long, and so close that they almost entirely cover the ground. Three or four days afterwards, the rear-guard follows, which consists of a straggling undisciplined troop of males and females. They travel chiefly during the night ; but, if it rains by day, (for moisture facilitates their motion), they proceed in their slow uniform manner.

* Voyage aux îles Francoises par Labat, tom. 2. page 221.

When the sun shines, and the surface of the ground is dry, they make an universal halt till the evening, and then resume their march. When alarmed with danger, they run backward in a disorderly manner, and hold up their nippers in a threatening posture. They even seem to intimidate their enemies ; for, when disturbed, they make a clattering noise with their nippers. But, though they endeavour to render themselves formidable to their enemies, they are cruel to each other. When an individual, by any accident, is so maimed that he cannot proceed, his companions immediately devour him, and then pursue their journey. After a fatiguing and tedious march, which sometimes continues three months before they reach the shore, they prepare themselves for depositing their spawn. The eggs still remain in the bodies of the animals, and are not excluded, as usual to this genus, under the tail. To facilitate the maturation and exclusion of the eggs, the land-crabs no sooner arrive on the shore, than they approach to the margin of the sea, and allow the waves to pass several times over their bodies. They immediately retire to the land ; the eggs, in the mean time, come nearer to maturity, and the animals once more go to the water, deposit their eggs, and leave the event to Nature. The bunches of spawn are sometimes as large as a hen's egg ; and it is not incurious to remark, that, at this very period, numbers of fishes of different kinds are anxiously waiting for this annual supply of food. Whether the painful migration of the land-crabs, or the wonderful instinct of the fishes which await their arrival, in order to devour their spawn, is the most astonishing fact, we shall leave to the consideration of philosophers. The eggs which escape these voracious fishes are hatched under the sand. Soon after, millions of minute crabs are seen leaving the shore, and migrating slowly toward the mountains. Most of the old ones, however, remain in the flat parts of the country till they regain their

strength. They dig holes in the earth, the mouths of which they cover with leaves and mud. Here they throw off their old shells, remain quite naked, and almost without motion for six days, when they become so fat that they are esteemed delicious food. When the new shell has hardened, the animals, by an instinctive impulse, march back to those mountains which they had formerly deserted. In Jamaica, where they are numerous, the land-crabs are regarded as great delicacies ; and they are so abundant, that the slaves are often fed entirely upon them.

The migrating principle is not confined to men, quadrupeds, birds, and reptiles : It extends to many of the *insect* tribes. Numberless inhabitants of the air pass the first stages of their existence in the waters. There they remain for longer or shorter periods, according to the species. Previous to their transformation into chrysalids, they quit the waters, and come upon dry ground, where they undergo their amazing change. Instead of active water-worms, they dig or find holes in the earth, where they are converted into chrysalids, or seemingly inanimate beings, and, in a short time, mount into the air in the form of winged insects. Similar migrations are to be observed among land-insects. But migration is not confined to water-worms. Many species of caterpillars which feed upon the leaves of trees, shrubs, and other vegetables, when about to undergo their transformation, leave their former abodes, descend from the trees, and conceal themselves in the earth. The hiving of bees, when numerous colonies remove in order to establish new settlements, is another instance of the migration of insects. Indeed, if we except bees, wasps, ants, and a few others, most insects, whether they inhabit the air, the earth, or the waters, are perfect wanderers, having no fixed place of residence. Some of them, as the spider tribes, build temporary apartments ;

but, when disturbed, they migrate to another commodious place, and erect new habitations.

From the facts which have been enumerated, it is apparent, that the principle of migration, or the desire of changing situations, is not confined to particular birds, but extends through almost the whole system of animation. Men, quadrupeds, birds, fishes, reptiles, insects, all afford striking examples of the migrating principle. From the same facts it is equally apparent, that the general motives for migrating are similar in every class of animals. Food, multiplication of species, and a comfortable temperature of air, are evidently the chief causes which induce animals to remove from one place to another, or, what amounts to the same thing, from one climate to another. Partial emigrations, or emigrations to small distances, are prompted by the same instinctive motives which induce animals of a different structure to undertake long and fatiguing excursions. But, previous to actual migration, what are the peculiar feelings of different animals, and what should stimulate them to proceed uniformly in the direction that ultimately leads them to the situations most accommodated to their wants and their constitutions, are mysteries, with regard to which, like every other part of the oeconomy of Nature, it is the duty of philosophers, instead of attempting to push their inquiries beyond the bounds of human ability, to observe a respectable silence.

CHAPTER XXI.

Of the Longevity and Dissolution of Organised Bodies.

IT is a law of Nature, though a melancholy one, that all organised bodies should be dissolved. The periods of dissolution, however, are as various as the species, and the intentions of Nature in producing them.

In the human kind, the brevity of life is regarded as an object of regret. One half of mankind die before they arrive at eight years of age. From that early period to eighty, beside the destruction of war, and other accidents, Nature kills them annually in millions. Some instances may be given of men whose lives were prolonged beyond the usual period of human existence. Such men are not to be envied ; nor should they be considered as favourites of Nature. With respect to maturity of judgment, and a knowledge of the world, no man can be said to exist till he passes thirty years of age. Give him thirty or thirty-five more, and, in general, both mind and body are visibly declined. Those people, therefore, who arrive at an extraordinary age may be said to exist, but they do not live. All intellectual enjoyments and exertions, which constitute the chief dignity and happiness of man, are gone. There are exceptions ; but these exceptions are confirmations of what we have advanced. Mankind, in the early ages of the world, have been said to live for several centuries. We mean not to contradict the assertion. But we must remark, that, if ever men lived so long, they must have been very different both in the structure of their bodies and in their manners, from those who now exist. From infancy to manhood, there is a gradual growth or extension of our organs. After this period, and when we ad-

vance in years, the bones harden, the muscles turn stiff, the cartilages are converted into bones, the membranes into cartilages, the stomach and bowels lose their tone, and the whole fabric, instead of being soft, flexible, and obedient to the inclinations, or even the commands of the mind, becomes rigid, inactive, and feeble. These are the general and progressive causes of death, and they are common to all animals. There are modes of living more favourable to health than others. But examples are not wanting of men who have arrived at extreme old age, without observing either temperance, or any of the other modes of living which are generally supposed to be favourable to longevity. Some men, who lived temperately, and even abstemiously, have reached to great ages: Others, who observed the very opposite conduct, who lived freely, and often intemperately, have had their existence equally prolonged. But, in general, notwithstanding a few exceptions, temperance, a placid and cheerful disposition, moderate exercise, and proper exertions of mind, contribute, in no uncommon degree, to the prolongation of life.

A few examples of longevity in the human species, though no general conclusions can be drawn from them, may not be incurious to the reader. We shall not go back to a remote and obscure antiquity, but confine ourselves to more modern times, when the modes of living were nearly the same as they are at present.

On this subject, the celebrated Lord Verulam, in his *Sylva Sylvarum**, gives the following passage, chiefly translated from the seventh book of Pliny's Natural History : ' The year of our Lord seventy-six, falling into the time of Vespasian, is memorable ; in which we shall find, as it were a kalender of long-lived men : For that year there was a taxing, (now a taxing is the most authentical and truest informer touching the ages of men), and in that part of Italy which lieth between the Appennine mountains and the river Po,

* Page 293.

' there were found 124 persons that either equalled or exceed an hundred years of age, namely,

' Fifty-four	-	-	-	-	of 100 years each.
' Fifty-seven	-	-	-	-	110
' Two	-	-	-	-	125
' Four	-	-	-	-	130
' Four	-	-	-	-	135 or 137
' Three	-	-	-	-	140
' Beside these, Parma, in particular, afforded five, whereof,					
' Three were	-	-	-	-	120 years each.
' Two	-	-	-	-	130
' One in Bruxelles	.	-	-	-	125
' One in Placentia	-	-	-	-	131
' One in Faventia	-	-	-	-	132
' A certain town, then called Velleiatium, situate in the hills about Placentia, afforded ten, whereof					
' Six were	-	-	-	-	110 years each.
' Four	-	-	-	-	120
' One in Rimino, whose name was					
' Marcus Aponitus	-	.	.	-	150.'

The most extraordinary instance of longevity in Great Britain was exhibited in the person of Henry Jenkins. He was a native of Yorkshire, lived to the amazing age of 169 years, and died on the 8th day of December 1670.

Next to Jenkins we have the famous Thomas Parre, who was a native of Shropshire, and died on the 16th day of November 1635, at the age of 152.

Francis Conisit, a native of Yorkshire, aged 150, died in January 1768.

Margaret Forster, aged 136, and her daughter, aged 104, were natives of Cumberland, and both alive in the year 1771.

William Evans, aged 145, lived in Carnarvon, and still existed in the year 1782.

Dumiter Radaloy, aged 140, lived in Harmenstead, and died on the 16th day of January 1782.

James Bowels, aged 152, lived in Killingworth, and died on the 15th day of August 1656.

The Countess of Desmond, in Ireland, saw her 140th year.

Mr. Ecleston, a native of Ireland, lived to the age of 143, and died in the year 1691.

John Mount, a native of Scotland, saw his 136th year, and died on the 27th day of February 1776.

William Ellis of Liverpool died on the 16th day of August 1780, at the age of 130.

Colonel Thomas Winsloe, a native of Ireland, aged 146, died on the 22d day of August 1766.

John Taylor was born in Carrygill, in the county of Cumberland. He was bred a miner. His father died when John was only four years of age. Poverty obliged him to be set early to work. During two years he dressed lead ore for 2 d. a-day. The next three or four years he assisted the miners in removing the ore and rubbish to the bank, for which he received 4 d. a-day. At this period there happened a great solar eclipse, which was distinguished in Scotland by the appellation of *Mirk Monday**. This event, which he always repeated with the same circumstances, is the chief aera from which John's age has been computed. After labouring many years both in this and the neighbouring kingdom, he died, near Leadhills in Scotland, in the month of May 1770, at the great age of 133.

Though the above modern examples of extraordinary longevity rest chiefly on the authority of periodical publications, yet there is not a doubt, that, in all countries, and at all times, some persons of both sexes have arrived at ages far beyond the common periods of human life. If the reader is

* Mirk, in the Scottish dialect, signifies dark; and the eclipse happened in the year 1652.

desirous of seeing many instances of longevity, he may consult Bacon's *History of Life and Death* *, Whitehurst's *Inquiry into the Original State and formation of the Earth* †, and Dr. Fothergill's *Observations on Longevity* ‡.

The general causes of death have already been mentioned. But, in women, the operation of these causes is frequently retarded. In the female sex, the bones, the cartilages, the muscles, as well as every other part of the body, are softer and less solid than those of men : Neither are they generally so much subjected to bodily exertions. Their constituent parts, accordingly require more time in hardening to that degree which occasions death. Women of course ought to live longer than men. This reasoning is confirmed by the bills of mortality ; for upon consulting them, it appears, that, after women have passed a certain time, they live much longer than men who have reached the same period. The duration of the lives of animals may in some measure be estimated by the time occupied in their growth. An animal, or even a plant, as we learn from experience, which acquires maturity in a short time, perishes much sooner than those which are longer in arriving at that period. In the human species, when individuals grow with uncommon rapidity, they generally die young. This circumstance seems to have given rise to the common proverbial expression, *soon ripe soon rotten*. Man grows in stature till he be sixteen or eighteen years of age ; but the thickness of his body is not completely unfolded before that of thirty. Dogs acquire their full length in one year ; but their growth in thickness is not finished till the end of the second. A man, who continues to grow for thirty years, may live ninety or a hundred : But a dog, whose growth terminates in two or three years, lives only ten or twelve. The same observation is applicable to

* *Sylva Sylvarum*, page 273. &c.

† 2d Edit page 165.

‡ *Annual Register, Natural History division*, page 61.

most animals. Fishes continue to grow for a great number of years. Some of them, accordingly, live during several centuries ; because their bones and cartilages seldom acquire the density of those of other animals. It may, therefore, be considered, as a general fact, that large animals live longer than small ones, because the former require more time to complete their growth. Thus the causes of our dissolution are inevitable ; and it is equally impossible to retard that fatal period, as to change the established laws of Nature. When the constitution is sound, life may, perhaps, by moderating the passions, and by temperance, be prolonged for a few years. But the varieties of climate, and the modes of living, make no material differences with regard to the period of our existence, which is nearly the same in the European, the Negro, the Asiatic, the American, the civilized man and the savage, the rich and the poor, the citizen and the peasant. Neither does the difference of food, or of accommodation, make any change on the duration of life. Men who are fed on raw flesh or dried fish, on sago or rice, on cassada or roots, live as long as those who use bread and prepared viuctuals. If luxury and intemperance be excepted, nothing can alter those laws of mechanism which invariably determine the number of our years. Any little differences which may be remarked in the term of human life, seem to be chiefly owing to the quality of the air. In general, there are more old men in high than in low countries. The mountains of Scotland, of Wales, and of Switzerland, have furnished more examples of longevity than the plains of Holland, Flanders, Germany, or Poland. But if we take a survey of mankind, whatever be the climate they inhabit, or their mode of living, there is scarcely any difference in the duration of life. When men are not cut off by accidental diseases, individuals may every where be found who live ninety or an hundred years. Our ancestors, with few exceptions, never exceeded

this period ; and, since the days of David King of the Jews, it has undergone no variation. Beside accidental diseases, which are more frequent, as well as more dangerous, in the latter periods of life, old men are subjected to natural infirmities that originate solely from a decay of the different parts of the body. The muscles lose their tone, the head shakes, the hands tremble, the limbs totter, the sensibility of the nerves is blunted, the cavities of the vessels contract, the secretory organs are obstructed, the blood, the lymph, and the other fluids, extravasate, and produce all those symptoms and diseases which are commonly ascribed to a vitiation of the humours. The natural decay of the solids, however, appears to be the original cause of all these maladies. It is true, that a bad state of the fluids proceeds from a depravity in the organization of the solids. But the effects resulting from a noxious change in the fluids produce the most alarming symptoms. When the fluids stagnate, or if, by a relaxation of the vessels, an extravasation takes place, they soon corrupt, and corrode the weaker parts of the solids. Hence the causes of dissolution gradually, but perpetually, multiply, our internal enemies grow more and more powerful, and at last put a period to our existence.

With regard to *Quadrupeds*, the causes of their dissolution are precisely the same with those which destroy the human species. The times of their growth bear, likewise, some proportion to the duration of their lives. But, as we have already given a table of the ages at which different quadrupeds are capable of multiplying their species, and of the general duration of their lives, to avoid unnecessary repetitions, we must refer the reader to page 288 of this work.

Some *Birds* afford instances of great longevity. In this class of animals, the duration of life is by no means proportioned to the times of their growth. Most of them acquire their full dimensions in a few months, and are capable of multiplying

the species the first spring or summer after they are hatched. In proportion to the size of their bodies, birds are much more vivacious, and live longer than either men or quadrupeds. Swans have been said to live three hundred years ; but, though mentioned by respectable writers, the assertion is not supported by any authentic evidence. Mr. Willoughby, in his *Ornithology**[†], remarks, ‘ We have been assured by a friend of ours, a person of very good credit, that his father kept a goose known to be fourscore years of age, and as yet sound and lusty, and like enough to have lived many years longer, had he not been forced to kill her for her mischievousness, worrying and destroying the young geese and goslings.’ In another part of this valuable work, Mr. Willoughby tells us, ‘ that he has been assured by credible persons, that a goose will live a hundred years or more.’

In man and quadrupeds, the duration of life bears some proportion to the times of their growth. But, in Birds, their growth, and their powers of reproduction, are more rapid, though they live proportionally longer. Some species of birds, as all the gallinaceous tribes, can make use of their limbs the moment they issue from the shell ; and, in a month or five weeks after, they can likewise employ their wings. A dung-hill cock has the capacity of engendering at the age of four months, but does not acquire his full growth in less than a year. The smaller birds are perfect in four or five months. They grow more rapidly, and produce much sooner than quadrupeds, and yet they live proportionally much longer. In man and quadrupeds, the duration of life is about six or seven times more than that of their growth. According to this rule, a cock or a parrot, who arrive at their full growth and powers in one year, should not live above

* Page 14.

† *Ornithology*, page 256.

fix or seven. But Nature knows none of our rules. She accommodates her conduct, not to our shallow, and often presumptuous conclusions, but to the preservation of species, and to the support and general balance of the great system of animated beings. Ravens, though capable of providing for themselves in less than a year, sometimes have their lives protracted more than a century. The Count de Buffon informs us, that, in several places of France, ravens have been known to arrive at this extraordinary age, and that, at all times, and in all countries, they have been esteemed birds of great longevity*.

‘Eagles,’ says Mr. Pennant, ‘are remarkable for their longevity, and for their power of sustaining a long abstinence from food. A golden eagle, which has now been nine years in the possession of Owen Holland, Esq. of Conway, lived thirty-two years with the gentleman who made him a present of it; but what its age was when the latter received it from Ireland is unknown. The same bird also furnishes a proof of the truth of the other remark, having once, through the neglect of servants, endured hunger for twenty-one days, without any sustenance whatsoever.’ The pelican that was kept at Mechlin in Brabant during the reign of the Emperor Maximilian, was believed to be eighty years of age. ‘What is reported of the age of eagles and ravens,’ says Mr. Willoughby, ‘although it exceeds all belief, yet doth it evince that those birds are very long-lived†. Pigeons have been known to live from twenty to twenty-two years. Even the smaller birds live very long in proportion to the time of their growth and the size of their bodies. Linnets, gold-finches, &c. often live in cages fifteen, twenty, and even twenty-three years.

* Hist. Nat. des Oiseaux, tom. 3. page 32.

† British Zoology, vol. 1. 8vo. edit. page 123.

‡ Ornithology, page 14.

Fishes, whose bones are more cartilaginous than those of men and quadrupeds, are long of acquiring their utmost growth, and many of them live to great ages. Gesner gives an instance of a carp in Germany which he knew to be one hundred years old*. Buffon informs us, that, in the Count Maurepa's ponds, he had seen carps of one hundred and fifty years of age, and that the fact was attested in the most satisfactory manner. He even mentions one which he supposed to be two hundred years old†. Two methods have been devised for ascertaining the age of fishes, namely, by the circles of the scales, and by a transverse section of the back-bone. When a scale of a fish is examined by the microscope, it is found to consist of a number of circles within one another, resembling, in some measure, those rings that appear on the transverse sections of trees, by which their ages are computed. In the same manner, the ages of fishes may be ascertained by the number of circles on their scales, reckoning for each ring one year of the animal's existence. The ages of Buffon's carps were chiefly determined by the circles on their scales. The age of fishes that want scales, as the skate and ray-kind, may be pretty exactly known by separating the joints of the back-bone, and observing minutely the number of rings which the surface exhibits. Both of these methods may be liable to deception; but they are the only natural ones which have hitherto been discovered. The longevity of fishes has been ascribed to several causes. The element in which they live is more uniform, and less subject to accidental changes than the air of our atmosphere. Their bones, which are more of a cartilaginous nature than those of land animals, admit of indefinite extension; of course, their bodies, instead of suffering the rigidity of age at an early period, which is the natural cause of death, continue to grow much longer than those of most land-animals.

Gesner de Pisc. page 312.

† Epoques de la Nature, page 181.

As to the age of *Reptiles*, probably from the uninteresting nature of the animals, we have very little information. But two letters of J. Arscott, Esq. ; of Tehott in Devonshire, concerning the longevity of a *toad*, deserve some notice. These letters were addressed to Dr. Milles, Dean of Exeter, and by him communicated to Mr. Pennant in the year 1768 : ‘ It would give me the greatest pleasure,’ says Mr. Arscott, ‘ to be able to inform you of any particulars worthy Mr. Pennant’s notice, concerning the toad who lived so many years with us, and was so great a favourite. It had frequented some steps before the hall-door some years before my acquaintance commenced with it, and had been admired by my father for its size, (which was of the largest I ever met with), who constantly paid it a visit every evening. I knew it myself above thirty years, and, by constantly feeding it, brought it to be so tame, that it always came to the candle, and looked up, as if expecting to be taken up and brought upon the table, where I always fed it with insects of all sorts. You may imagine that a toad, generally detested, (although one of the most inoffensive of all animals), so much taken notice of and befriended, excited the curiosity of all comers to the house, who all desired to see it fed; so that even ladies so far conquered the horrors instilled into them by nurses, as to desire to see it*.’ In the second letter, Mr. Arscott remarks, ‘ I cannot say how long my father had been acquainted with the toad before I knew it; but, when I was first acquainted with it, he used to mention it as the old toad I have known so many years; I can answer for thirty-six years†.’ ‘ In respect to its end, had it not been for a tame raven, I make no doubt but it would have been now living, who one day, seeing it at the mouth of its hole, pulled it out, and, though I rescued it, pulled out one eye,

* Pennant’s British Zoology, vol. 3. page 323.

† Ibid. page 326.

and hurt it so, that, notwithstanding its living a twelve-month, it never enjoyed itself, and had a difficulty in taking its food, missing the mark for want of its eye. Before that accident it had all the appearance of perfect health*.

Most *Insects*, especially after their last transformation, are short-lived. But the species are continually supported by their wonderful fecundity. Those animals whose parts require a long time of hardening and expanding are endowed with a proportional degree of longevity. *Insects* grow, and their bodies harden, more quickly than those of larger animals. Many of them complete their growth in a few weeks, and even in a few days. The duration of their existence is accordingly limited to very short periods. Some species of flies lie in a torpid state during the winter, and revive when the heat of spring or summer returns. The ephemeron flies, of which there are several kinds, seldom live above one day, or one hour, after their transformation. But, to continue the species, Nature has taken care that myriads of males and females should be transformed nearly at the same instant. Were it otherwise, the males and females could have no opportunity of meeting, and the species would soon be extinguished. Other kinds are transformed more irregularly, and live several days. Here the wisdom of Nature is conspicuous : She prolongs the existence of these animals for no other purpose but to allow the individuals of both sexes to meet and multiply the species. Bees, and flies of all kinds, after lying long in water, and having every appearance of death, revive by the application of a gentle heat, or by covering their bodies with ashes, chalk or sand, which absorb the superfluous moisture from their pores. Reaumur made many experiments upon the reviviscence of drowned bees. He found, that, after being immersed in water for nine hours, some of them returned to life ; but he acknowledges that

* Pennant's British Zoology, vol. 3. page 332.

many of them, in the fourth part of this time, were actually dead, and that neither heat, nor the application of absorbent powders, could restore them to life. Analogical reasoning is often deceitful, but it frequently leads to useful truths. As flies of all kinds, after immersion in water, and exhibiting every mark of actual death, can be restored to life by covering their bodies with any absorbent substance, without the assistance of a heat superior to that of the common atmosphere, might not the ordinary methods employed for the recovery of drowned persons be assisted by the application of warm ashes or chalk? The structure of a fly and that of a man, it is allowed, are very different. But, in desperate cases, when every other method fails, no fact should be overlooked, and no analogy despised.

Plants differ as much in the periods of their existence as animals. Many plants perish yearly; others are biennial, triennial, &c. But the longevity and magnitude of particular trees are prodigious. We are informed by Mr. Evelyn, that, in the bodies of some English oaks, when cut transversely, three, and even four, hundred rings of wood have been distinguished. A ring of wood is added annually to the trunks of trees; and, by counting the rings, the age of any tree may be pretty exactly ascertained*. With regard to the magnitude of oaks, some of them are huge masses. Dr. Hunter, in his Notes upon Evelyn's *Sylva*, remarks, that none 'of the oaks mentioned by Mr. Evelyn bear any proportion to one now growing at Cowthorpe, near Wetherby, upon an estate belonging to the Right Hon. Lady Stourton. The dimensions are almost incredible. Without in three feet of the surface, it measures sixteen yards, and close by the ground, twenty-six yards. Its height, in its present and ruinous state, (1776,) is about eighty-five feet, and its principle limb extends sixteen yards from the bole.

* See Evelyn's *Sylva*, page 505.

‘ When compared to this, all other trees are but *children* of
‘ of the forest*.’

From the facts which have been enumerated, it appears, that all animals, as well as vegetables, have stated periods of existence, and that their dissolution is uniformly accomplished by a gradual hardening and desiccation of their constituent parts. No art, no medicine, can retard the operations of Nature. It is, therefore, the wisdom and the duty of every human being to fail down the irresistible current of Nature with all possible tranquility and resignation. Life, whether short or long, whether fortunate or unfortunate, when the fatal period arrives, is of little consequence to the individual. Society, knowledge, virtue, and benevolence, are our only rational enjoyments, and ought to be cultivated with diligence.

With regard to animals in general, the actual duration of their lives is very different. But the comparative shortness or length of life, in particular animals, probably depends on the quickness or slowness of the ideas which pass in their minds, or of the impressions made upon their senses. A rapid succession of ideas or impressions makes time seem proportionally long. There is likewise a connection between the quickness and slowness of ideas, and the circulation of the blood. A man whose pulse is slow and sluggish, is generally dull and phlegmatic. Raise this same man’s pulse with wine, or any other exhilarating stimulus, and you immediately quicken his sensations, as well as the train of his ideas. In all young animals, the circulation of the blood is much more rapid than after they have acquired their full growth. Young animals, accordingly, are frolicksome, vivacious, and happy. But, when their growth is completed, the motion of blood is slower, and their manners, of course, are more sedate, gloomy, and pensive. Another circum-

* Ibid. page 500.

stance merits attention. The circulation of the blood is slower or quicker in proportion to the magnitude of animals. In large animals, such as man and quadrupeds, the blood moves slowly, and the succession of their ideas is proportionally slow. In the more minute kinds, as mice, small birds, squirrels, &c. the circulation is so rapid that the pulses of their arteries cannot be counted. Now, animals of this description astonish us with the quickness of their movements, the vivacity of their manners, and the extreme cheerfulness of their dispositions.

Reaumur, Condillac, and many other philosophers, consider duration as a relative idea, depending on a train of conscious perception and sentiment. It is certain that the natural measure of time depends solely on the succession of our ideas. Were it possible for the mind to be totally occupied with a single idea for a day, a week, or a month, these portions of time would appear to be nothing more than so many instants. Hence a philosopher often lives as long in one day, as a clown or a savage does in a week or a month spent in mental inactivity and want of thought.

This subject shall be concluded with a single remark: If it be true, and we are certain that it is so in part, that animals of every species, whatever be the real duration of their lives, from a slow or rapid succession of ideas, and perhaps from the comparative intensity of their enjoyments, live equally long, and enjoy an equal portion of individual happiness, it opens a wonderful view of the great benevolence of Nature. To store every portion of this globe with animal life, she has amply peopled the earth, the air, and the waters. The multifarious inhabitants of these elements, as to the actual duration of their lives, are extremely diversified. But, by variation of forms, of magnitude, of rapidity of ideas, of intensity of pleasures, and, perhaps, of many other circumstances, she has conferred upon the whole nearly an equal portion of happiness.

CHAPTER XXII.

Of the Progressive Scale or Chain of Beings in the Universe.

TO men of observation and reflection, it is apparent, that all the beings on this earth, whether animals or vegetables, have a mutual connection and a mutual dependence on each other. There is a graduated scale or chain of existence, not a link of which, however seemingly insignificant, could be broken without affecting the whole. Superficial men, or, which is the same thing, men who avoid the trouble of serious thinking, wonder at the design of producing certain insects and reptiles. But they do not consider that the annihilation of any one of these species, though some of them are inconvenient, and even noxious to man, would make a blank in Nature, and prove destructive to other species who feed upon them. These, in their turn, would be the cause of destroying other species, and the system of devastation would gradually proceed, till man himself would be extirpated, and leave this earth destitute of all animation.

In the chain of animals, man is unquestionably the chief or capital link, and from him all the other links descend by almost imperceptible gradations. As a highly rational animal, improved with science and arts, he is, in some measure, related to beings of a superior order, wherever they exist. By contemplating the works of Nature, he even rises to some faint ideas of her great Author. Why, it has been asked, are not men endowed with the capacity and powers of angels? beings of whom we have not even a conception. With the same propriety, it may be asked, why have not beasts the mental powers of men? Questions of this kind

are the results of ignorance, which is always petulant and presumptuous. Every creature is perfect, according to its destination. Raise or depress any order of beings, the whole system, of course, will be deranged, and a new world would be necessary to contain and support them. Particular orders of beings should not be considered separately, but by the rank they hold in the general system. From man to the minutest animalcule which can be discovered by the microscope, the chasm seems to be infinite : But that chasm is actually filled up with sentient beings, of which the lines of discrimination are almost imperceptible. All of them possess degrees of perfection or of excellence proportioned to their station in the universe. Even among mankind, which is a particular species, the scale of intellect is very extensive. What a difference between an enlightened philosopher and a brutal Hottentot ? Still, however, Nature observes, for the wisest purposes, her uniform plan of graduation. In the human species, the degrees of intelligence are extremely varied. Were all men philosophers, the business of life could not be executed, and neither society, nor even the species, could long exist. Industry, various degrees of knowledge, different dispositions, and different talents, are great bonds of society. The Gentoos, from certain political and religious institutions, have formed their people into different castes or ranks, out of which their posterity can never emerge. To us, such institutions appear to be tyrannical, and restraints on the natural liberty of man. In some respects they are so : But they seem to have been originally results of wisdom and observation ; for, independently of all political institutions, Nature herself has formed the human species into castes or ranks. To some she gives superior genius and mental abilities ; and, even of these, the views, the pursuits, and the tastes, are most wonderfully diversified.

In the talents and qualities of quadrupeds of the same species, there are often remarkable differences. These differences are conspicuous in the various races of horses, dogs, &c. Even among the same races, some are bold, sprightly, and sagacious. Others are comparatively timid, phlegmatic, and dull.

Our knowledge of the chain of intellectual and corporeal beings is very imperfect; but what we do know gives us exalted ideas of that variety and progression which reign in the universe. A thick cloud prevents us from recognising the most beautiful and magnificent parts of this immense chain of being. We shall endeavour, however, to point out a few of the more obvious links of that chain, which falls under our own limited observation.

Man, even by his external qualities, stands at the head of this world. His relations are more extensive, and his form more advantageous, than those of any other animal. His intellectual powers, when improved by society and science, raise him so high, that, if no degrees of excellence existed among his own species, he would leave a great void in the chain of being. Were we to consider the characters, the manners, and the genius of different nations, of different provinces and towns, and even of the members of the same family, we should imagine that the species of men were as various as the number of individuals. How many gradations may be traced between a stupid Huron, or a Hottentot, and a profound philosopher? Here the distance is immense; but Nature has occupied the whole by almost infinite shades of discrimination.

In descending the scale of animation, the next step, it is humiliating to remark, is very short. Man, in his lowest condition, is evidently linked, both in the form of his body and the capacity of his mind, to the large and small orang-outangs. These again, by another slight gradation, are con-

nected to the apes, who, like the former, have no tails. It is wonderful that Linnaeus, and many other naturalists, should have overlooked this gradation in the scale of animals, and maintained, that the island of Nicobar, and some other parts of the East Indies, were inhabited by tailed men. Before those animals whose external figure has the greatest resemblance to that of man, are ornamented, or rather deformed, with tails, there are several shades of discrimination. The larger and smaller orang-outangs, which are real brutes, have no tails. Neither are the numerous tribes of apes furnished with this appendage. But the believers in tailed men gravely tell us, that there is nothing surprising in this phenomenon, because a tail is only a prolongation of the *os coccygis*, which is the termination of the back-bone. They consider not, however, that, instead of accounting for the existence of tailed men, they do nothing more than substitute a learned circumlocution for the simple word *tail*. It is here worthy of remark, that a philosopher, who has paid little attention to natural history, is perpetually liable to be deceived ; and that a naturalist, I mean a nomenclator, without philosophy, though he may be useful by mechanically marking distinctions, is incapable of enriching our minds with general ideas. A proper mixture of the two is best calculated to produce a real philosopher. From the orang-outangs and apes to the baboons, the interval is hardly perceptible. The true apes have no tails, and those of the baboons are very short. The monkeys, who form the next link, have long tails, and terminate this partial chain of imitative animals, which have such a detestable resemblance to the human frame and manners.

When examining the characters by which beings are distinguishable from each other, we perceive that some of them are more general, and include a greater variety than others. From this circumstance all our distributions into classes, or-

ders, genera, and species, are derived. Between two classes, or two genera, however, Nature always exhibits intermediate productions so closely allied, that it is extremely difficult to ascertain to which of them they belong. The polypus, which multiplies by shoots, or by sections, from its body, connects the animal to the vegetable kingdom. Those worms which lodge in tubes composed of sand, seem to link the insects to the shell and crustaceous animals. Shell-animals and crustaceous insects make also a near approach to each other. Both of them have their muscles and instruments of motion attached to external instead of internal bones. From reptiles, the degrees of perfection in animal life and powers move forward in a gradual but perceptible manner. The number of their organs of sense, and the general conformation of their bodies, begin to have a greater analogy to the structure of those animals which we are accustomed to consider as belonging to the more perfect kinds. The snake, by its form, its movements, and its mode of living, is evidently connected with the eel and the water-serpent. Like reptiles, most fishes are covered with scales, the colours and variety of which often enable us to distinguish one species from another. The forms of fishes are exceedingly various. Some are long and slender; others are broad and contracted. Some fishes are flat, others cylindrical, triangular, square, circular, &c. The fins of fishes, from the medium in which they live, are analogous to the wings of birds. Like those of reptiles, the heads of fishes are immediately connected to their bodies, without the intervention of necks. The flying fishes, whose fins resemble the wings of bats, form one link which unites the fishes to the feathered tribes. Aquatic birds succeed, by a gentle gradation, the flying fishes.

In tracing the gradations from fishes to quadrupeds, the transition is almost imperceptible. The sea-lion, the morse, all the cetaceous tribes, the crocodile, the turtle, the seals,

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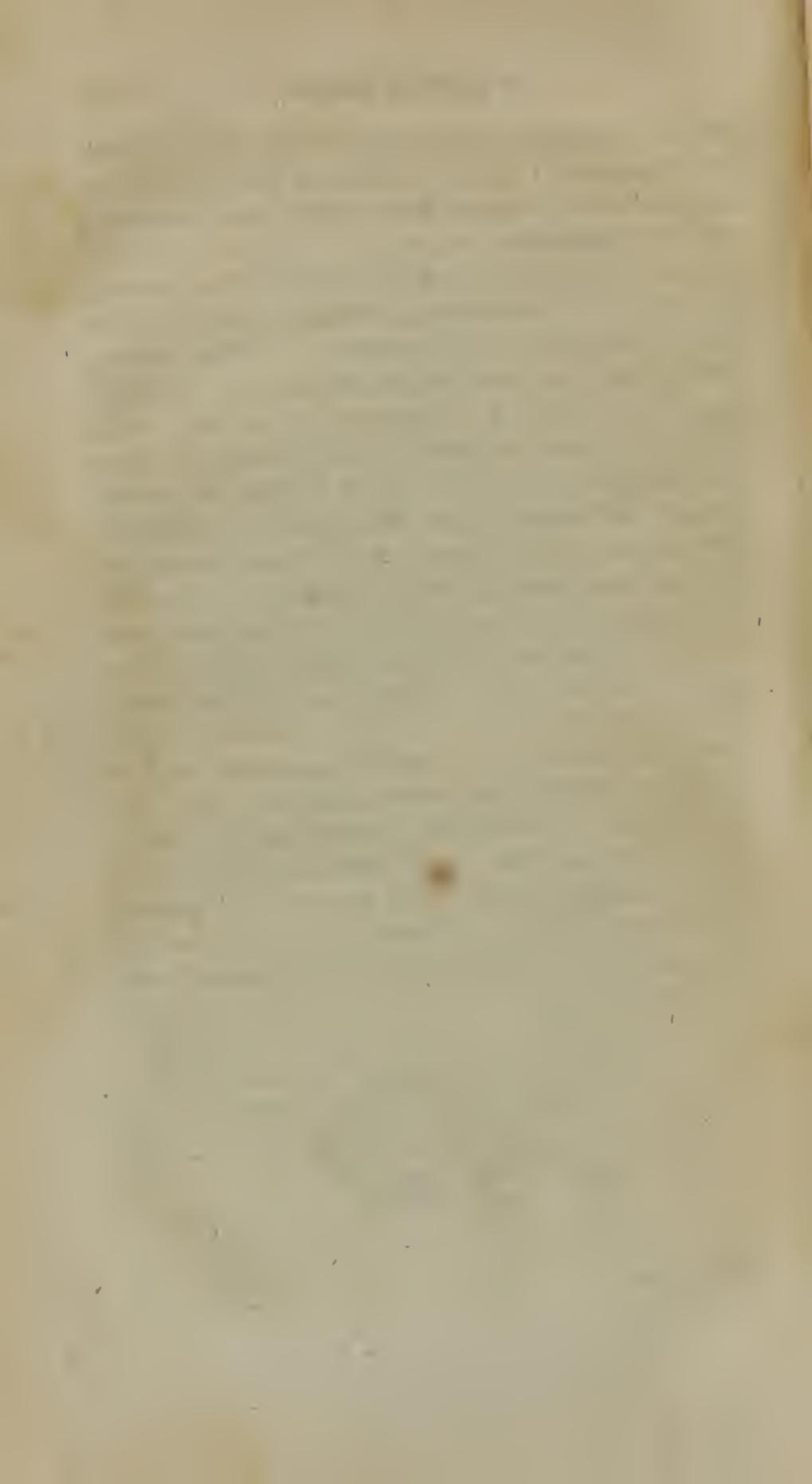
have such a resemblance, both in their external and internal structure, to terrestrial quadrupeds, that some naturalists, in their methodical distributions, have ranked them under the same class of animals. The bats and the flying squirrels, who traverse the air by means of membranous instead of feathered wings, evidently connect quadrupeds with birds. The ostrich, the cassowary, and the dodo, who rather run than fly, form another link between the quadruped and the bird.

All the substances we recognise on this earth may be divided into organised and animated, organised and inanimate, and unorganised, or brute matter. The whole of these possess degrees of perfection, of excellence, or of relative utility, proportioned to their stations or ranks in the universe. Change these stations or ranks, and another world would be necessary to contain and support them. Beings must not be contemplated individually, but by their rank, and the relations they have to the constituent parts of the general system of Nature. Certain results of their natures we consider as evils. Destroy these evils, and you annihilate the beings who complain of them. The reciprocal action of the solids and fluids constitutes life, and the continuation of this action is the natural cause of death. Immortality on this earth, therefore, presupposes another system ; for our planet has no relation to immortal beings. Every animal, and every plant, rises, by gentle gradations, from an embryo, or gelatinous state, to a certain degree of perfection exactly proportioned to their several orders. An assemblage of all the orders of relative perfection constitutes the absolute perfection of the whole. All the planets of this system gravitate toward the sun and toward each other. Our system gravitates towards other systems, and they to ours. Thus the whole universe is linked together by a gradual and almost imperceptible chain of existences both animated and inanimate. Were there no other argument in favour of the

UNITY OF DEITY, this uniformity of design, this graduated concatenation of beings, which appears not only from this chapter, but from many other parts of the book, seems to be perfectly irrefragable.

In contemplating Man, as at the head of those animals with which we are acquainted, a thought occurred, that no sentient being, whose mental powers were greatly superior, could possibly live and be happy in this world. If such a being really existed, his misery would be extreme. With senses more delicate and refined ; with perceptions more acute and penetrating ; with a taste so exquisite that the objects around him could by no means gratify it ; obliged to feed upon nourishment too gross for his frame ; he must be born only to be miserable, and the continuation of his existence would be utterly impossible. Even in our present condition, the sameness and insipidity of objects and pursuits, the futility of pleasure, and the infinite sources of excruciating pain, are supported with great difficulty by cultivated and refined minds. Increase our sensibilities, continue the same objects and situation, and no man could bear to live. Let man, therefore, be contented. His station in the universal scale of Nature is fixed by Wisdom. Let him contemplate and admire the works of his Creator ; let him fill up his rank with dignity, and consider every partial evil as a cause or an effect of general good. This is the whole duty of man.





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